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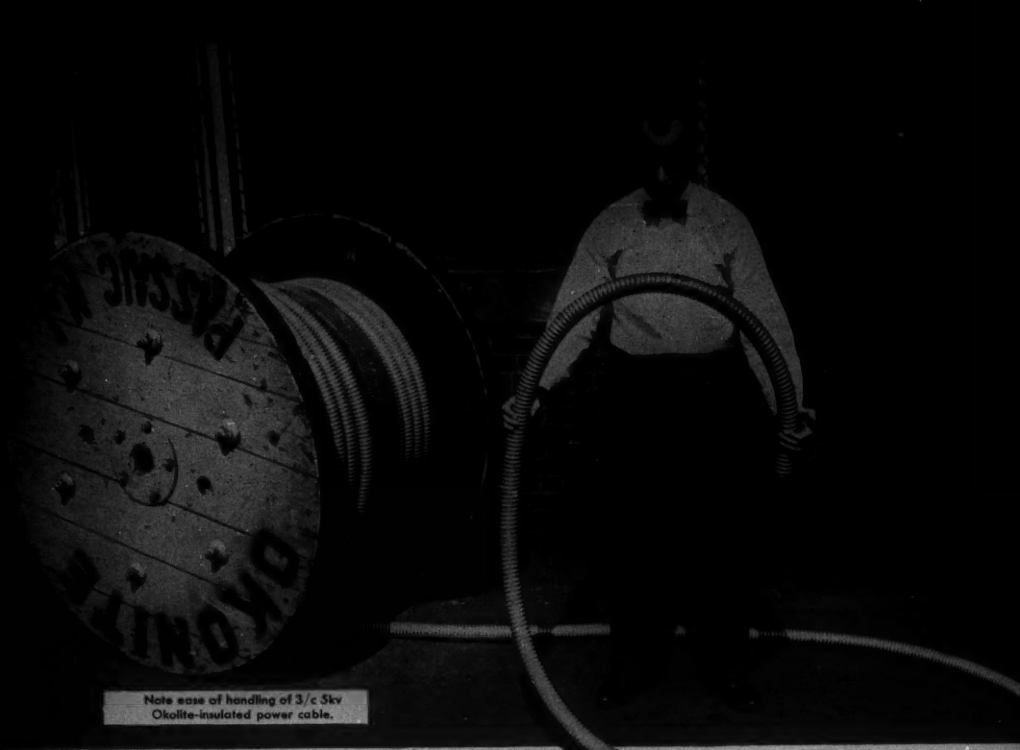

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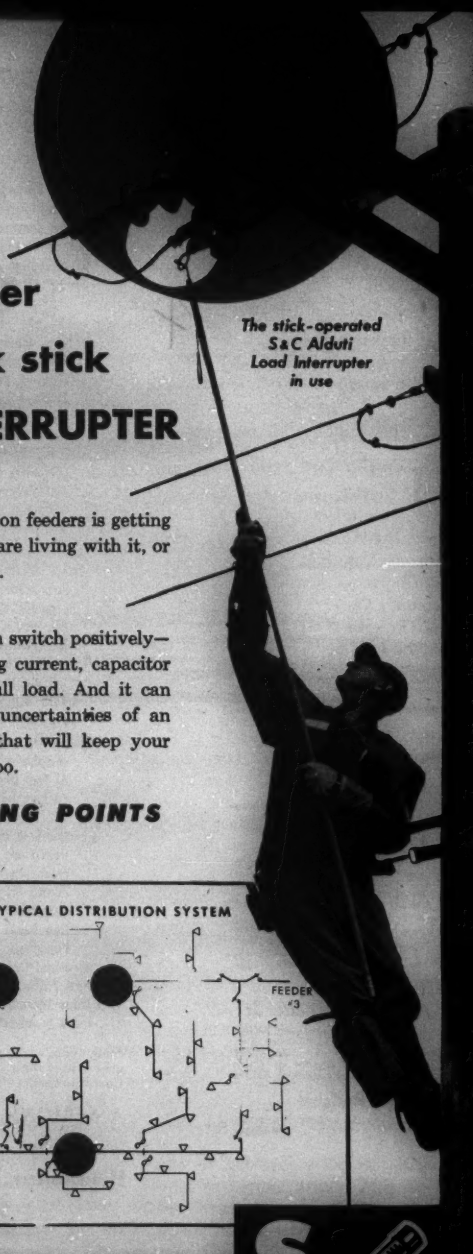

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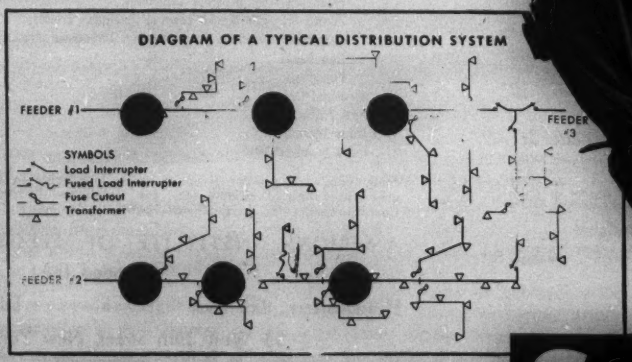

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SYSTEMS ENGINEERING
A Growing Concept

E. W. ENGSTROM
FELLOW AIEE

The concept of systems engineering is explained in terms of its evolution and characteristics. The engineering of a color television system and of a specific weapons system are used to illustrate its application.

THE TASK of adapting our increasingly complex devices and techniques to the requirements and limitations of the people who must use them has presented modern engineering with its greatest challenge. To meet this challenge, we have come to rely increasingly during recent years upon the comprehensive and logical concept known as systems engineering.

The growth of the system concept and its application to the solution of complex engineering problems are matters of interest to all of us engaged in developing new products, techniques, and services. With this growth has developed a close interrelationship among all of the functions encompassed by engineering, focusing them upon the basic objective of adapting technology to people and their needs.

SYSTEMS ENGINEERING DEFINED

WHAT DO WE MEAN by systems engineering? The many popular definitions boil down to the simple fact that systems engineering is a method of going about our business. This method is best described by stating the two major requirements for its success: first, a determination of the objective that is to be reached; and second, a thorough consideration of all factors that bear upon the possibility of reaching the objective, and the relationships among these factors.

There is nothing new about the practice of systems engineering. As a method, it has been employed for many years without the benefit of specific designation. John Ericsson's *Monitor* of the Civil War era is an early and outstanding example of systems engineering.

What is new is not the practice, but our recognition of it by name and our appreciation of its universal value. Only recently have we come to realize that in systems engineering lies the effective method for solving the most difficult problems raised by today's complex undertakings in the engineering field.

EVOLUTION OF SYSTEMS ENGINEERING

OUR APPRECIATION is not an overnight development. The systems approach has figured prominently for many years in the engineering of our modern telephone systems and the distribution of electric power. In the 1930's the concept was adopted in the research and development of our modern television service. This latter work is an outstanding example of the method as applied to electronics.

The experience of World War II gave the greatest impetus to the extension of the systems approach over a far broader area, largely because of developments in electronics. The need for many novel types of electronic gear for airborne use gave rise to a wide variety of component devices, popularly known as "black boxes." These included radar equipment, novel bomb sights, fire-control systems, and communications equipment. These were ingenious devices, but their application in terms of the entire system of which they were merely parts was a matter of improvisation. The practice, under wartime circumstances and pressures, was to think largely of the individual component and its use, rather than of the general environment in which it was to operate.

Inevitably, the proliferation of "black boxes" brought problems of establishing proper interaction among them. Thus, the systems engineer began to come into his own, performing the essential task of looking ahead to the ultimate objective—the system—and considering the whole of which each "black box" formed a part.

Under the unique pressures of World War II, the old approach succeeded in "grafting" novel electronic devices onto existing planes and vehicles. It would hardly suffice today for such tasks as the design of an earth satellite, an intercontinental missile, an electronic data-processing system, or a nuclear reactor.

CHARACTERISTICS OF THE SYSTEMS METHOD

WE NOW RECOGNIZE systems engineering as a discipline in its own right, having a set of rules affecting its conduct, requiring people with specialized training, and calling for substantial changes in our engineering organizations.

As a discipline, the systems approach has these characteristics in all cases, regardless of the great variety of objectives and detailed engineering methods:

1. It is broad in scope, ignoring the boundaries that separate the various academic disciplines, that separate research from engineering, and advanced development from product design and marketing.
2. It is co-operative, usually involving large numbers of people and functions that may appear at first glance to have little to do with one another.
3. It requires compromise, because success in developing a complex system normally involves a sacrifice at one

E. W. Engstrom is senior executive vice-president, Radio Corporation of America, New York, N. Y.

To the systems engineer, computation and display equipment like this at RCA's Waltham, Mass., laboratory provides the means for simulating the performance of the desired system or its component parts.

or more points of detail for the sake of the whole system.

4. It is thorough—and by the same token a bit skeptical. The systems engineer must examine every detail that bears upon the function of the complete system. At the same time, he must distrust the tempting "easy" solution that first appears.

There is one more highly important point to be emphasized. The principal reason for developing most systems is to surmount the limitations of human perception, physiology, or temperament. This is true whether the system involves the control of a supersonic plane, the solution of a complex mathematical problem, or the operation of a telephone dial.

The all-important question of human limitations is the basis of human engineering, a related discipline which has now become an integral part of the systems approach. We deal in the field of human engineering with such questions as the amount of detail that will satisfy the human eye in a television system, or the maximum number of controls that an aircraft pilot can handle safely. A lack of proper human engineering can be costly, or even catastrophic. On the other hand, proper consideration of human engineering factors in a design can contribute to success.

The success of a systems engineering approach invariably can be judged, then, by its effectiveness in producing a sound physical design, adapted for use by persons of defined skills, and based upon concepts resulting from an operational research analysis.

THE PEOPLE AND THE ORGANIZATION

THE SYSTEMS APPROACH is a complex matter, increasing in complexity as we move up the scale to larger and more involved units. Because each system must be considered as a unit, inattention to any single aspect of the smallest component can jeopardize success in attaining the final objective. Thus the question of success or failure rests, as it always has, upon the competence and reliability of the people to whom our engineering projects are entrusted.

The engineering team engaged in any systems project will normally include a number of individuals of varied technical skills, having in common the ability to fit their special talents into the achievement of the complete system. This team frequently will call upon specialists who do not have the systems viewpoint to refresh and enlarge their knowledge of the various technical specialties. While it is true that leadership of this team will reside in one man, the essential work of systems engineering on a project of any magnitude is done by the team and not by an individual.

A broad range of scientific and technical specialties is encompassed by such a team. There may be aerodynamicists, ballistics experts, electrical engineers, designers, mathematicians, physicists, chemists, psychologists and many others, in a variety of combinations according to the task at hand. In a fully co-operative team, a wide range of talents is thus brought to bear on each problem. Such a team has both positive and negative virtues. It is able not only to advance directly to a desired objective, but also to prevent a waste of time, effort, and expense on impractical projects.

The supervision and team activities of systems engineering clearly demand engineers of superior knowledge, vision, and tact. They must be equipped, above all, with the ability to apply standards which will enable them to judge the progress of the detailed work in relation to the final objective. Such engineers are developed through special training and through experience in an environment that encourages the flowering of their talents.

Many companies today maintain special training programs for systems engineers. RCA, for example, has cooperated with the Moore School of Electrical Engineering of the University of Pennsylvania in the establishment of a two-year graduate seminar course in systems engineering at the university. In the words of the prospectus, this course is planned

"(1) to supplement, for use in systems engineering or operations research, the education of persons of suitable experience in industry, graduate work, government service, or an equivalent, and

"(2) by concentrating on systems problems to inculcate a 'systems consciousness'."

RCA engineers selected for their potential effectiveness as systems engineers are given the opportunity to take this course after completing a preliminary lecture course within the company.

COLOR TELEVISION

THE DEVELOPMENT of the RCA compatible color television system is an outstanding example of systems engineering on a large scale.

At the outset, the systems engineers concerned with this complex project were faced with a series of basic conditions and problems. They had to establish first that there was a need for color television. Then it was necessary to determine that color television was both technically possible and economically feasible.

Subsequently, they had to consider the environment in which color television would start, grow, and continue.

This was a most important consideration since, for practical reasons, black-and-white television came first, creating a large and growing public investment in black-and-white television receivers. In this environment, the systems engineers concluded that the new color system must be compatible with the existing black-and-white service. In other words, the color system must be so designed that color broadcasts could be received in monochrome on existing black-and-white receivers, while the new color receivers could receive black-and-white as well as color broadcasts.

In retrospect, the choice of a compatible system seems utterly logical—but it was not so in the earlier development period. In fact, an incompatible system urged by some in the industry was approved as standard by the Government regulatory body. This move later had to be undone before further progress could be made toward establishment of a practical color television service.

Another broad problem for the systems engineering team was the definition of technical specifications. Involved in this question were such considerations as balancing the requirements of human vision for picture detail and color characteristics, and balancing the potentials of apparatus performance and the availability of channel space for broadcasting stations.

In the latter case, early analysis indicated a need for basic advances in technology and invention to fit picture information into a narrower frequency band than could be achieved by earlier straightforward communication techniques. It was evident, too, that new apparatus would have to be invented or developed—particularly the picture tube for reproducing color images. There was a clear need as well for broad experience in propagating the radio signals and transmitting color programs.

As the work moved beyond these initial determinations into the more practical stages, a host of more detailed problems had to be solved. These related to practical apparatus design, practical operation under broadcast service conditions, industry participation in determining the signal specifications for transmission, and approval of these specifications as standards by the Federal Communications Commission.

Finally, there came the problems of establishing color television service, expanding studies, interconnecting networks, installing transmitters, and creating program production groups. In the final stage, too, arose the matters of selling color to television advertisers, marketing the new receivers, and measuring public reaction.

Thus, from concept to fruition, the color television system presents a "textbook" example of the systems concept in action. All of these matters required full consideration by the systems engineering team, working toward the single defined objective.

A SPECIFIC SYSTEMS PROJECT

CREATION of the color television system represents the systems approach on the broadest scale. Yet the concept is fully as applicable on a narrower or more specific basis. We can see in the development of a military weapon how the same pattern of systems engineering emerges.

We do not need to be specific in this case as to the exact nature of the weapon. It might be a tactical system such as an aircraft for close support of ground troops, or it might be a strategic system such as an intercontinental ballistic missile. In any case, the systems engineering group must begin with a basic study in order to achieve the following objectives:

1. Determine the requirements for the weapon. How does it fit into the scheme of military tactics or over-all operational plans for the time period when it will be operational?

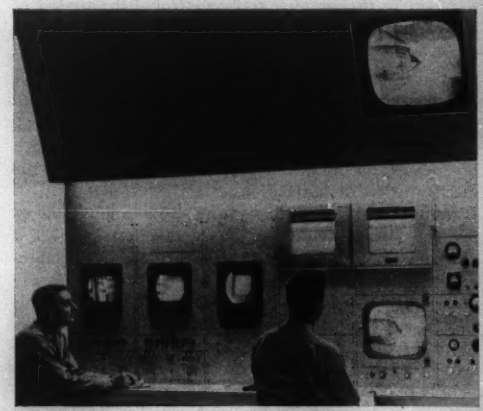
2. Determine the technical state of the art, and the prospects for advancement in the technical areas applicable to the problem.

3. Determine the optimum system that can be achieved in terms of the various functions, or subobjectives, that are involved. This analysis will include establishing a scale of values for the various functions, and determining the penalties incurred through cost, size, weight, or engineering complexity. This step frequently leads to compromise based on the most favorable ratio of value versus penalty, with the aim of achieving more important objectives at the expense of those which are relatively less important.

4. In cases where the ultimate solution of a part of the problem may still be only a gleam in the engineer's eye, determine whether interim solutions will permit development of the system as a whole pending ultimate development of the lagging individual parts.

5. Determine whether the system can be developed so that it can be operated by personnel with the training (or lack of it) that will be available.

6. Determine whether the system can be maintained in operation under field conditions. How much degradation is to be expected during use in the field? Should there be compromise between theoretical performance and field



Modern systems engineering employs modern tools. Here design problems involved in aircraft propulsion systems are studied by means of closed-circuit television, itself a product of a careful systems approach.

performance for the sake of achieving a greater probability of effective tactical use?

7. Determine whether the system can be supported logistically in the planned operating area. For example, should standard components be used extensively to ease field maintenance problems, or would this degrade performance of the weapon too seriously?

8. Determine whether the equipment will be subject to countermeasures by the enemy, such as jamming. At the same time, a determination should be made as to how far the system should be complicated by including safeguards against such enemy action.

9. Determine the extent to which a systems concept and design are susceptible to control by human operators under the conditions of use. For example, the human operator may in many cases be a part of the system, and his probable reactions and his level of training must be taken into account in designing the system.

All of these objectives fit into the general problem which the systems engineering team must resolve. Each of the answers from this resolution must be included in the design concepts and in the operation of the completed system.

These two examples—the engineering of a broad color television system and of a specific weapons system—are far apart in their concept and application. However, a common thread runs through both in the analysis and the execution of the work. Both present design problems that submit to the systems engineering concept. Clearly, both a color television system and a new military weapon call for the same kind of careful study and analysis, and the same application of appropriate skills to the variety of problems related to the final over-all objective. These requirements apply with equal force in all cases, whether the objective is an electronic business machine for a life insurance company, an accounting system for a bank, an inventory control system for a large business firm, or even a system for the complete traffic control of the airways of our country.

BROADER SIGNIFICANCE OF SYSTEMS ENGINEERING

SYSTEMS ENGINEERING is enabling us today to reap maximum benefits from new, expanding, scientific and technical knowledge. At the same time, it is providing us with broader experience of immense value in preparation for the coming era of automation.

Automation in its ultimate form will encompass all aspects of systems engineering, on the broadest scale. For a generation of engineers trained in the design of comprehensive systems, it will be a relatively short step in the philosophical sense from the electronic data-processing systems of today to the automatic factories of tomorrow. It will be just as short a step from today's largely automatic jet fighter to tomorrow's completely automatic jet airliner operating in an environment of controlled traffic.

The complexity that has overtaken our technology has at the same time overtaken our economy, our social environment, and our relationships with the rest of the world. There is every reason to believe that this complexity, like that in the field of technology, will increase rather than decrease in the future.

Many of these complexities arise from changing or evolving relationships between racial or economic groups, between nations, and between conflicting ideologies. In each case, we must start with the determination of an objective, and with a thorough consideration of all factors bearing upon the possibility of reaching this objective. We must make ourselves aware of the relationships among these factors. We must consider the limitations of perception and temperament among the people upon whom the success of the proposed solution depends. There is a striking parallel here between the steps required to solve many problems in these broad areas, and those required by systems engineering in the field of technology.

The systems concept has been designed specifically to fulfill requirements in the engineering of complex systems. Its effectiveness can be measured by our success in developing wonderfully versatile systems of home entertainment, communications, automatic controls, and military weapons. In each case, application of the concept has led to new achievement through imaginative planning, effective and extensive teamwork in a worthy enterprise, and an ability to compromise when necessary to achieve the desired objective.

Surely a philosophy which encourages these traits need not be confined in the future to the field of technology alone.

Sodium Reactor Experiment

Scheduled to be in operation this year is the Sodium Reactor Experiment, a nuclear power plant being built by Atomics International, a division of North American Aviation, Inc., as part of the Atomic Energy Commission's program to develop economical power from atomic energy. Heat from the nuclear reactor (in background building) will be converted to electricity in experimental amounts by generating equipment installed by the Southern California Edison Company. The project is located about 30 miles northwest of Los Angeles, Calif.

Carbon Brush Capacity Calculations

J. G. WILHITE
ASSOCIATE MEMBER AIEE

THE SIZE AND NUMBER of carbon brushes required for current-collection systems are usually determined from some arbitrary selection of current density in the brush face. For critical designs where limited space requires high surface velocities and high current densities, such a method has proved to be inadequate. On many of these designs, the ultimate capacity of the brushes has been reached and some have exceeded the capacities of certain brush grades.

Carbon-brush capacity and performance characteristic curves are the basis for a method of calculation by which the optimum design constants for current-collection systems can be determined. The characteristic curves are obtained from brush performance tests on high-speed, high-temperature commutators driven by variable-voltage d-c motors. Measurements of brush current, contact drop voltage, coefficient of friction, and commutator surface temperatures can be taken under all test conditions. This brush-capacity method applies to commutator and collector ring designs for either a-c or d-c operation.

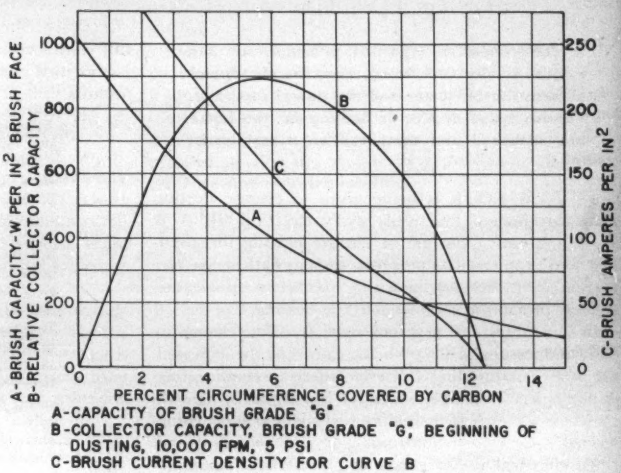


Fig. 1. Carbon brush quantity and rating for optimum capacity.

Brush capacity is defined as the sum of friction and contact-drop watts per square inch of brush face at the condition of speed and current density which causes the brushes to disintegrate into clouds of visible dust. Brush capacity is a function of the percentage of the commutator circumference covered by carbon brushes (per-cent CCC). This function is a logarithmic curve which approaches a definite capacity limit as per-cent CCC is reduced toward zero. From this value, the curve drops logarithmically as per-cent CCC increases. At high speeds and high brush-finger pressure, the friction wattage becomes the major portion of the brush capacity, with only a small portion of the brush capacity left over for contact drop losses.

The optimum quantity of carbon for a given design is determined by calculating the "relative capacity" as a function of per-cent CCC. "Relative capacity" is the product of per-cent CCC and the current density corresponding to the per-cent CCC values. The per-cent CCC for which the "relative capacity" is maximum determines the quantity of carbon brushes for which the maximum brush performance and life may be expected.

Fig. 1 gives the quantity (per-cent CCC) and rating (amperes per square inch) for various finger pressures and for three values of surface velocity.

A sample design is given for a 1,500-ampere (maximum) 6-pole machine which has a 16¼-inch diameter commutator running at 10,000-feet-per-minute surface velocity, and having a brush pressure of 5 pounds per square inch. From curve 2, optimum per-cent CCC is 5.9 per cent and corresponding current density (at the beginning of dusting, curve 5) is 160 amperes per square inch.

The brush thickness is 5.9 per cent of the commutator circumference divided by the number of brush holders around the commutator or $(5.9/100)\ (16\frac{1}{4}\ \pi)/6 = \frac{1}{2}$ inch. The current capacity of the commutator per inch of length at the brush density of 160 amperes per square inch is equal to the brush thickness times the current density times the number of brush arms of like polarity or $(\frac{1}{2})\ (160)\ (6/2) = 240$ amperes per inch of commutator length.

For 1,500 amperes (maximum), the commutator length required is 1,500/240 or 6¼ inches. A standard brush nearest this size might be ½ by 2 inches with three brushes per arm for a total of 18 brushes for this machine. The normal rating from Fig. 1, curve 6 is 80 amperes per square inch, or 750 amperes for this machine.

Digest of paper 56-943, recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., October 1-5, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1956.

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Electric Heating in the Home

S. L. FORSYTH

A comprehensive report is presented on the subject of electric heating, from the standpoint of both the consumer and the power company. Various types of electric heating for the home are discussed and compared on a cost basis.

A NEW LOOK is being given to electric heating for homes. Practically every electrical utility is welcoming the use of electric heating for auxiliary and supplemental purposes, such as bathrooms, recreation rooms, etc. An increasing number of utilities are actively promoting complete electric heating.

In some cases, this new look stems from the change in daily and seasonal demands being caused by the increased use of air conditioning. But even where air conditioning is not a factor, complete electric heating is being welcomed as a means of increasing revenue and broadening service.

An electrical utility promotes electric heating to increase revenue. One electrical utility summarized exhaustive tests in these terms any business man can understand:

Average	Without Heating	With Heating	Per-Cent Increase
Demand, kw	7.5	13.2	76
Kw-hr	8,454	20,500	148
Revenue	$122.54	$224.01	82

Their average electric-heating customer increases revenue by 82% and kilowatt-hour usage by 148%. Yet the peak demand increased by only 76%.

This happens to be a system where the kilowatt-hours used by the nonheating customer is extremely high. Had the usage been around average, the increase created by electric heating might have been over 300%, while the demand increased by no more than 100%.

The results achieved on another system might be altogether different but it is clear that electric heating for homes offers an opportunity to sell kilowatt-hours that far exceeds any other prospects.

For estimating kilowatt-hour consumption, there is in popular use a formula relating installed capacity to "degree days." Its most common form is

$$KW\text{-}HR = \frac{KW \times DD}{TD} \times C$$

Although this formula will give an approximation of the kilowatt-hours needed under average conditions, it must be used with care. As with all calculating formulas, full consideration must be given to the accuracy of the factors used and the tolerance limits permissible. In this formula

$KW\text{-}HR$ = Estimated annual kilowatt-hour consumption for a normal heating season under average conditions.

KW = Calculated heating capacity required for design conditions. Remember that certain assumptions are made in determining this factor so that it is never an absolute quantity.

DD = Degree days per average heating season. One degree day is a theoretical measure of the amount of heating required for one day and is defined as the number of degrees between 65 F and the actual mean daily temperature for a given day; for example, when the mean daily temperature is 10 F on a specific day, 55 degree days of heating will be required. However, degree day data is an illusive factor which must be used with care. It is based on the average outside temperature. Two areas having the same average temperature may vary considerably in their heating requirements; for example, an area where the temperature was 10 F for 16 hours and 40 F for 8 hours would have the same average temperature as an area where the temperature was 10 F for 8 hours and 40 F for 16 hours. The degree day data would be the same but nearly 30% more electricity would be required for the first condition than for the second condition. The use of degree day data obtained by adding degree hour data gives more reliable estimates and should be used wherever possible.

TD = Temperature difference between inside and outside design temperature. Usually 70 F is taken as the inside temperature but where it is known that the inside temperature will be higher, that figure should be used. The selection of outside design temperature is a matter of judgment and experience, but it is seldom taken as the lowest recorded temperature. Generally accepted design temperatures for any locality can be obtained from the U.S. Weather Bureau or one of the many published tables such as the one in the NEMA (National Electrical Manufacturers Association) or the Westinghouse Electric Heating Guide (B-3768B).

C = Correction factor. Theoretically it should be 24 but, because of the many variables, it is usually less. The FHA (Federal Housing Administration) has been using a factor of 20 for all installations and NEMA recently published 18.5 as a "conservative value," but neither gives full consideration to the large influence exerted by the type of equipment and the thermostatic control used. In general, the correction factor decreases as the number of thermostats used to control a given heating capacity increases. It is always less for equipment that puts the heat directly into the room.

The results of extensive tests by several reliable electrical utilities, reported in various publications and substantiated by years of experience with thousands of installations, show that a correction factor of 12 is the most practical for applications using nonfan-type unit heaters with built-in thermostats. For embedded cable heating systems, a minimum value of 17 has sometimes been used, but most manufacturers have been recommending a value of 20. Twenty is the minimum value

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that should be used for central furnaces and floor furnaces.

The correction factor to be used in any area should be determined by the local electrical utility with full consideration being given to the type of equipment installed. No one correction factor can be used for all kinds of equipment and all areas. And never should the formula be taken as absolutely accurate for even one condition. The living habits of the user are much more important and will always determine the actual kilowatt-hour consumption.

Many different studies show that electric-heating customers use more kilowatt-hours for other purposes. A large Midwestern electric utility recently revealed that during June of last year, homes equipped with electric heating used more than three times the kilowatt-hours used by their average domestic customers—737 kw-hr compared to 227 kw-hr. There was hardly any air-conditioning load and, according to weather reports, there was no need for heat, so the increase must have come from other uses.

Those other uses are extremely important because they all subtract from the heating load. Whenever a light is turned on, it gives off heat. While the electric range is cooking food, it is also heating the kitchen. Heat from the water used in a shower or bath warms the bathroom.

DIVERSITY OF DEMAND

Consideration must also be given to diversity of demand. Experience has shown that the distribution capacity required to serve an isolated house usually needs to be only 60% of total connected load. Where 10 or more electrically heated homes are served by the same system, the installed distribution capacity needs to be only about 30% of total connected load. This is particularly true if the electric heating equipment consists of individual units, each with a built-in thermostat, and the distribution system is of the current-protected banked-secondary type.

It should be remembered, also, that the lowest ambient temperature exists when maximum electric heating demands occur. A distribution system can often handle winter peak electric heating load demands that are two or three times as great as the summer peak loads. In one system, for example, 40 kw of electric heating is successfully served with only 15 kva additional transformer capacity.

Some electrical utilities have tried to control demand by using regulating devices, by raising the end rate block or by application of a penalty demand charge. Such steps have generally resulted in headaches that far exceed the benefits. Those treating electric heating as merely another part of the ever growing total domestic load are having the most success.

In most cases, electric heating trebles the annual kilowatt usage per residential customer. It creates demands that are no worse than those caused by ranges, water heaters, and driers. It can be a profitable load builder.

Electric heating makes it practically certain that the electrical utility will get the revenue available from electric cooking and electric water heating. Heat electrically and everything goes electric—the truly "all-electric" home is created.

Electric heating furthers the adequate wiring program. There is not a single new home using electric heating that is not considered adequately wired. The service entrance is 100 amperes or more. Branch circuits are adequate, but more can be added without difficulty when needed.

Electric heating strengthens the electrical industry. It increases the electrical portion of house construction cost from less than 2% to around 7%. It gives to the electrical contractor that share of the building business that formerly went to the plumber. It increases business for electrical wholesalers and equipment manufacturers. It makes the electrical industry healthier.

COST

Wherever electricity can be purchased for 1.5¢ per kw-hr or less, electric heating is competing with oil at 16¢ per gallon. In some cases, a higher power rate is competing with oil at a lower price.

In making operating cost comparisons, "use efficiency" is often overlooked. By "use efficiency" is meant that proportion of the energy supplied which is actually used to create comfortable surroundings. It is extremely important in making operating cost comparisons.

A good electric heating system uses all the energy available. It supplies comfort where you need it when you want it. There is no need to heat the entire house just to get comfort in one or two rooms.

With a central fuel-burning heater system, combustion losses reduce efficiency. There is also a reduction in efficiency resulting from the inherent characteristics of such systems. No matter how much or how little heat is required, the entire output of the system must be turned on. Often the amount of heat actually used will be only a small fraction of the energy available in the fuel. This is particularly true on mild days when the "use efficiency" of the combustion system is extremely low.

Operating a large capacity heating system—even one using low-cost fuel—can often be more expensive than turning on an electric heater.

However, operating cost alone does not tell the complete story. Consideration must be given to all factors influencing total cost, and any comparison must be made on a total-cost basis.

The installation cost of a good electric heating system runs about 50 or 60% of a comparable combustion heating system. There is no need to pay for duct work or storage space and no chimney is required. This is of considerable interest to builders who are always looking for ways to reduce the cost of a house. Since the initial cost is less, the interest and depreciation charges are reduced, an important factor to home owners.

A good electric heating system has no moving parts to wear or cause trouble; therefore, maintenance costs are negligible.

Even if the over-all cost is a little higher, the difference will be more than offset by the benefits. No other heating

system offers the convenience, flexibility, cleanliness, and efficiency available with electric heating.

EQUIPMENT

THE BEST EQUIPMENT for electric heating is the kind that will do the best job at the lowest cost. Heat is needed, not to warm the body, but to provide comfortable surroundings so that the body will not lose heat too rapidly. The human body constantly produces heat. Just sitting still, each person generates heat at the rate of about 500 Btu per hour (a little over 100 watts)—enough heat to bring a quart of water to the boiling point.

A person walking generates heat at the rate of 750 Btu per hour. Running, the rate is three or four times that amount. The human body is a machine that converts the energy present in food into work, as the automobile converts the energy in gasoline into work. And, like the automobile, the human body generates more energy than it can use.

What happens to this excess energy? The body throws it off as heat to the surrounding air. If it did not, body temperature would increase, and it is well known that increasing body temperature above 98.6 F is dangerous.

Some heat is given off by convection, the process which transfers heat to the air about the body. Some is radiated from the body to the walls, furniture, and surroundings. And, of course, heat is carried away by the evaporation of sweat.

The amount given off by each of these methods depends upon many factors and their complicated interrelationship. Just how the human body adjusts itself to all the various surroundings is not known. But it is known that the body is always generating heat, some of which must be given off.

The fundamental thermodynamic processes can be represented by the equation

$$M = \pm S + E \pm R \pm C$$

where

M = Metabolism, the heat produced by the body
S = Heat storage, the change in the intrinsic body heat
E = The evaporation heat loss
R = The radiation heat lost or gained
C = The convection heat lost or gained

The metabolism M is always positive. The storage S may be positive or negative depending upon whether heat is being stored or taken away from the body. The evaporative loss E is always positive. Both R and C are positive when body surface temperature is above that of the walls and air, and negative when it is below.

At temperatures which produce comfort and at all lower temperatures, the production of sweat is low and heat lost by evaporation is relatively low and relatively constant, irrespective of the relative humidity of the atmosphere. Under such conditions, as in the home, the heat loss from the body is related chiefly to the combined effect of convection and radiation.

The heat lost by radiation depends upon the exposed surface of the body, its mean surface temperature and the mean surface temperature of the surroundings. The thermodynamic relationships are similar to those encountered in determining heat losses from copper wires and other electrical apparatus.

The heat lost by convection depends upon the temperature differences between the surface of the body and the surrounding air, the shape and size of the body, and the rate of air motion over the body.

These various heat losses supplement each other, and complicated controls within the body function to keep the equation in balance whenever there is a change in surroundings.

When a person is comfortable, excess heat will be carried away in about this proportion: 1/5 by evaporation of moisture from the skin; 2/5 by convection to the air moving around a person; and 2/5 by radiation to the surroundings. Under these conditions, the human system will be balanced. The temperature of the surroundings will be between 65 and 85 F. Usually 70 F is considered the ideal temperature.

When the surroundings change, complicated controls within the body make readjustments in an effort to balance heat losses to fit the surroundings. The body temperature remains the same 98.6 F, and a person feels hot or cold depending upon his surroundings.

If the air temperature goes down, a person's heat loss by convection increases. If the person is standing near a cold window or cold wall, heat loss by radiation increases. In either case, he feels cold because heat loss balance has been changed and his body tends to lose heat more rapidly.

The quickest way to feel warm is to restore the balance by standing in front of a heat source which supplies radiation. One may feel warm in the sunshine even though the ground is covered with snow and the temperature is below freezing, because the heat received by radiation from the sun compensates for the greater amount of heat lost by convection to the cold air.

If a person receives radiation when the temperature is about 70 F, he feels too warm. Because the body is receiving heat on one side, the amount of heat given off by radiation is reduced by one-half. Usually the convection cannot be increased, so the body increases its evaporation to restore the balance.

Normally, for comfort, heat is not supplied to the body. The surroundings are heated so that the body will not lose heat too rapidly. Any great change in the relationship between convection, radiation, and evaporation is undesirable.

For the average human indoors, comfort will be obtained when the air and walls are about the same temperature and air movement is not too rapid. Theoretically, it makes little difference how one creates these conditions; one can heat the ceiling or wall and let them heat the air or one can heat the air and let it heat the walls. When comfort exists, the temperature will be about 70 F. Practical considerations determine the type of heating system that will be used.

Since practical considerations dominate, electric heating is growing, because it offers conveniences and flexi-

bility which cannot be obtained in any other way. No labor is required as with shoveling coal or removing ashes. No storage space is needed for fuel and there is no danger from open flame or explosive substances. No oxygen is taken from the air and obnoxious gases are not produced.

METHODS

ELECTRIC HEATING METHODS can be classified into seven basic types:

1. Central warm-air systems.
2. Central wet systems.
3. Off-peak systems.
4. Heat pump systems.
5. Panel heating systems.
6. Floor furnaces.
7. Unit heater systems.

The classification "central warm-air systems" applies to those methods which employ a central furnace and deliver warm air through ducts to the various areas where the heat is needed.

Central wet systems are those which employ pipes and some form of radiator filled with either steam or hot water for delivering the heat from an electric boiler to the location where it is used.

Off-peak heaters include all storage type of heaters which require no electricity input during certain times of the day. They are, of necessity, a variation of the first two methods because they require either ducts or pipes to deliver the heat from the place where it is generated or stored to the place where it is wanted; however, the characteristics of off-peak heaters warrant a separate classification for them.

The heat pump is interesting because both heating and cooling can be provided by the same equipment. However, as with the off-peak heaters, the heat pump needs air ducts or pipes to distribute the heat. Therefore, it must be considered as another furnace when it is used for heating.

Panel heating systems include all those methods which heat the ceiling, the floor, the walls, or other large areas. These systems have been greatly misnamed "radiant heating systems." Their temperature has to be so low for comfort that only a small portion of the heat is dissipated by radiation. In fact, the panels become merely convectors.

Floor furnaces include those devices which recess beneath the floor and discharge warm air level with the floor or through registers in a wall.

Unit heater systems include all types of heaters which are a unit in themselves, designed to heat one room independent of all other rooms. Many kinds are available. Some employ fans and others must depend upon natural

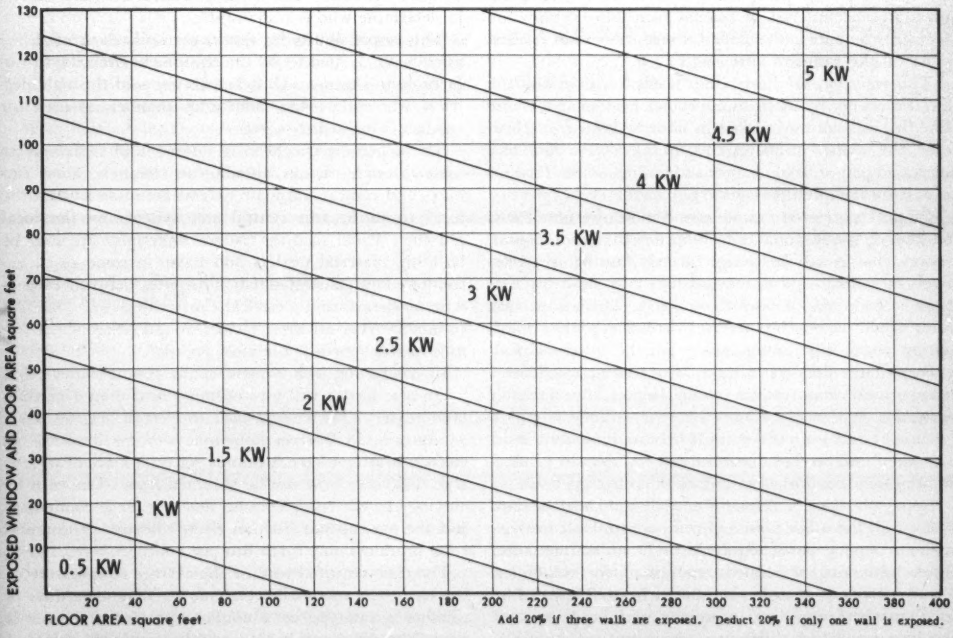

Fig. 1. Electric heating capacity required, where outside temperature is 10 F. (For single-story house, single glass, 4-inch insulation on ceiling, 2-inch insulation on walls.)

thermal currents to keep the air circulating throughout the room.

In choosing a practical electric heating method, there are 10 practical considerations which need to be compared. Table I shows how the seven classifications of electric heating methods compare with each other on these considerations.

Table I. Comparison of Heating Methods

	Central Warm-Air Systems	Central Wet Systems	Off-Peak Systems	Heat Pump Systems	Panel Heating Systems	Floor Furnaces	Unit Heater Systems
1. First cost	4	5	6	7	3	1(?)	2
2. Kilowatt-hour cost	6	7	2(?)	1(?)	4	5	3
3. Maintenance cost	4	5	6	7	3	2	1
4. Reliability	3	4	5	7	6	2	1
5. Flexibility	3	4	7	6	5	2	1
6. Controllability	3	4	5	7	6	2	1
7. Power demand	3	4	7	2	5	6	1
8. Satisfaction to home owner	2	5	7	4	3	6	1
9. Responsibility for results	3	4	6	5	7	2	1
10. Sales channels	3	5	6	7	4	2	1
TOTAL	34	47	57	53	46	30	13

This comparison used arbitrary numbers to indicate which electric heating method is the most popular. Number 1 indicates that it ranks highest; number 7, that it ranks lowest.

On first cost, floor furnaces may lead because a form of simple heating can be obtained at low cost. However, they tend to heat the area locally just as old-fashioned stoves did. This is particularly true where low temperatures are encountered. If systems furnishing equal comfort are compared, the floor furnace soon loses its first place on this point to unit heaters.

Theoretically, the heat pump needs less than half the electric energy required by resistance heaters and, therefore, it has been ranked first in kilowatt-hour cost. However, the savings in energy cost do not always offset the increased cost of fixed charges and maintenance. That accounts for the question mark (?).

Off-peak systems are rated second in kilowatt-hour cost on the very questionable assumption that the off-peak energy charge will be lower. Electric heating is a relatively large load, and it does not take very many installations to make the off-peak the on-peak. This means that rates would have to be increased accordingly, thus eliminating power cost advantages. Also, the lower off-peak energy charge does not always offset the increased fixed charges and maintenance costs. Hence, the question mark (?).

Unit heaters are ranked third because most tests show that they usually consume less kilowatt-hours in producing the same comfort than any of the other methods.

Going on down Table I, note that unit heaters rank first on all the other points of comparison. Unit heaters, without moving parts, require little or no maintenance. They have long-established reputations for reliability. For flexibility of use, they are far in front. They can be used anywhere, any time, to provide auxiliary heat or all the heat needed. A different temperature can be maintained in each room, or one room at a time can be heated.

Unit heaters are the easiest to control because they do not have large thermal storage, and each one can have a built-in thermostat which responds quickly to small changes in room temperature. Individual control is extremely important because it gives a diversity of power demand which cannot be achieved with any other system so far known. Good diversity of power demand is of prime interest to utilities because it means less distribution capacity needs to be provided.

No true measure of satisfaction exists, because each person has his own ideas of what he wants. Unit heaters have been rated first because most of the people interviewed like their carefree, cheery warmth.

Under "Responsibility for results," unit heaters lead. A complete package requiring only simple electrical connections can be supplied by the manufacturer. Installation can be made by electrical contractors without the assistance of other tradesmen. Responsibility for results can be centralized. With all the other methods, at least two trades are involved. Responsibility for results is divided.

This point is very important to electrical utilities as well as to home owners. If a unit heater should give trouble, only part of the house will be without heat and the home owner has only to call his electrical contractor or dealer for service. Generally, the electrical utility is the first thought of the home owner when his electric heating system gives trouble. With the centralized responsibility afforded by unit heaters, the problem is easy. With all other systems, the utility might have to act as a referee to determine who is responsible.

This responsibility for results carries back through the sales channels used to get the equipment from the manufacturer to the user. Unit heaters are sold through electrical wholesalers—the same sales channels as used for conduit, wire, switches, etc.

The other electric heating systems find their way to users through various distribution channels. Floor furnaces and central warm-air systems are often sold by the local tinsmith, and central wet systems by the local plumber. Panel heating systems sometimes are sold by building material dealers and have, in some cases, encountered jurisdictional labor disputes between carpenters, plasterers, and electrical contractors.

Summarizing all these factors, it can be seen why the unit heater system is the most popular.

In comparing unit heaters, many people believe that a fan-type heater will give off more heat than a nonfan-type heater. This is not a fact. In electric heating, 1 kw produces 3,413 Btu per hour and blowing air across an electric heating element cannot generate more heat. It is true that more heat can be obtained from steam coils by moving the air faster because more steam is condensed. But the heat output from an electric heater is constant—1 kw produces only 3,413 Btu per hour.

The time required to raise the average temperature of the air in any room will be about the same regardless of whether a fan-type or a nonfan-type electric heater is used. The difference in time will be within the limits of good measuring practice.

Heaters circulating warm air by gentle thermal currents will maintain temperature within ±2 F in all parts of the room and create a feeling of stable comfort that cannot be obtained with other methods. Fan-type heaters often create harsh drafts and temperature variations up to 8 F. Fan-type heaters may be suitable for factories but not for homes.

Nonfan-type units specifically designed to supply some radiation for quick warmth and circulation without moving parts are the most popular. They probably will continue to be the most popular for the many reasons mentioned.

Wall models are used primarily for heating a home entirely by electricity, but they can be used for auxiliary heating. They come in many different sizes and heating capacities.

Floor models are primarily used for auxiliary heating, but they can also be used for heating a home entirely by electricity. They also come in many different sizes and heating capacities.

Baseboard models are a special type of unit heater. They replace the ordinary baseboard, providing a streamlined installation without sacrificing room space. Room interiors can be planned with complete freedom of arrangement. Chairs and davenports can be located any place.

The number of heating sections required to provide the correct heating capacity are easily fitted together to form a continuous unit. The control section contains a switch and thermostat which gives individual temperature control to each room.

Baseboard models, like other units, can be installed in existing rooms or in new construction. No major structural changes are required. Services of other trades are not involved. Responsibility for results is centralized.

With such a wide choice of types and sizes, the correct unit can be selected to fit individual requirements. They can be used to provide comfort in a single room or throughout the entire house.

HEATING CAPACITY

REGARDLESS OF THE TYPE of equipment used, it is extremely important that enough heating capacity is installed. A house, like the human body, is constantly giving off heat when it is warmer than its surroundings. The heat lost must be replaced so that comfortable surroundings will be maintained.

To reduce the amount of heat lost, the ceiling should always be insulated. The savings in heating costs will be about one-third in most cases and usually are enough to pay the original cost of the insulation within a few years. A more even temperature can be obtained throughout the house, and during the hot summer months the house will be cooler.

Heat escapes through glass very easily and also gets out through all cracks and openings. Storm windows and storm doors will reduce such heat losses by about 50%.

The minimum insulation should be the equivalent of 4 inches of blown-in mineral wool in the ceiling. Two-inch thick batt-type insulation with vapor seal should be used in the walls, and storm windows and doors should be used where they can be economically justified.

For a specific design condition, the heating capacity to be installed will always be the same regardless of the heating system used. Remember, heat is supplied to maintain comfortable surroundings, not to heat the body.

Determination of heating capacity required is really quite simple. It is like determining electric current flow using Ohm's law, only the terms are different.

$$KW = WA\ (T_i - T_o)$$

where

KW = Heating capacity needed. It is equal to total heat lost under design conditions

W = Heat transmission coefficient in watts per square foot per degree temperature difference. This is referred to as the "U" factor in heating terms. You need only remember that 3,413 Btu per hour equals 1 kilowatt to convert from one to the other. Generally accepted values for the "U" factor can be obtained from the ASHAE (American Society of Heating and Air-Conditioning Engineers) Guide or from any of the other tabulations available, such as those in the NEMA Manual

A = Area in square feet of surface through which heat is being lost

T_i = Inside temperature (usually 70 F)

T_o = Outside design temperature

In practice, the heat lost through each surface exposed to a colder temperature is calculated by substituting the proper data in this formula. A similar formula is used to determine the heat requirements due to infiltration. The individual values are added to get the total heat lost from a single room. The various room values are added to get the total heating capacity required for the house.

As with all calculations, tolerance limits must be considered. Generally, heating capacity determinations which are within 10% of each other are considered equal. For any one room, experience has shown that calculations within 500 watts have proved accurate enough. Where heating capacity installed in one room might be less than calculated, additional capacity should be used in another room to bring the total within design tolerance. Oversizing is definitely better than undersizing.

There have been developed several simplified calculating methods, using this fundamental formula as a base. Some use slide rules and some use charts.

The charts in the Westinghouse Electric Heating Guide, one of which is shown in Fig. 1, make it easy to determine heating capacity requirements after the floor area and window area are known. A number of utilities have adopted these charts as standard for their area.

It is of primary importance that sufficient heating capacity is installed. Insufficient capacity will only lead to complaints and dissatisfied users.

Normally, electric heating is sold and installed by electrical contractors. They are logical sales outlets for electric heating. Builders look to them for electrical wiring and equipment. Home owners look to them for wiring changes that may be necessary.

Electric heating for homes offers a challenging opportunity—a truly golden opportunity for a bright future.

Digital Computers Can Aid Utilities

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MEMBER AIEE

Some of the more common applications of digital computers in the electrical utility field are discussed. The emphasis is placed not only on their present-day uses, but also on their possible future utilization.

DURING THE PAST YEAR or so, many of the electrical utility companies have been seeking ways and means to make use of automatic digital computers for the solution of their engineering problems. A number of them have been using punched-card equipment in their billing and other financial and accounting operations, and would like to apply the experience gained there to their engineering work.

The first question to be answered is "What is a digital computer?" Stated simply, the digital computer combines the abilities of an arithmetic machine and a device for making logical decisions. First, then, it can count. This differentiates it from the more familiar analog machines —the a-c and d-c network analyzers, the transient analyzers, and the differential analyzers—in all of which quantities are measured. The digital computer not only can count, but also can count extremely rapidly and with almost no errors. It can remember thousands or even millions of numbers and find any one of these, and operate on it arithmetically in a very short time. But still more important it can make logical decisions. Based on the size of a number, or the relative magnitudes of two numbers, the machine will follow one or the other of two specified courses of action. The computer is somewhat analogous to a very logical human being with a desk calculator and volumes of data, who is setting out to do a long tedious calculation. The major distinctions are the far greater speed and error-free operation of the digital computer.

It is not necessary to be a comptometer operator to make good use of a digital computer for engineering work. The engineer must only be able to prepare a flow chart or logical description of the problem he wishes computed, and a programmer versed in the language of computers will be able to write out detailed instructions for the problem solution.

It should be emphasized that mere possession of an automatic digital computer does not endow one with supernatural powers. Problems must still be programmed, coded, and debugged, and very frequently the time for these operations is far greater than the total machine solution time of the problem. We frequently read of problems whose preparation required thousands of man-hours as contrasted with tens or hundreds of machine-solution-hours. With this sort of situation, the personnel problem assumes great importance. It is essential that we apply very high grade talent to programming for these machines so that we can take full advantage of their great speed capacity and accuracy.

This article was presented as a conference paper at the AIEE Fall General Meeting, Chicago, Ill., October 1-5, 1956. It is introductory to seven other papers presented under the sponsorship of the AIEE Committees on System Engineering and Computing Devices. The entire series of eight papers will be made available in a special publication at a later date.

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SPEEDING UP PRESENT CALCULATIONS

THE FIRST THING one would think of if a new tool such as a digital computer were available to him would probably be its application to the jobs he is now doing. If computers are fast, if they have great capacity, and operate without errors, let us apply them to some of the tedious jobs which now are being done manually. Often we are faced with statistical jobs whose arithmetic is very uncomplicated but where large amounts of data must be processed. Such jobs might include load forecasting or probability studies, to estimate reserve requirements. These problems do not require high-powered mathematics, but they are tedious and the hand calculator will surely make many errors in every such study she does. Heat-balance calculations are another example and there are surely many electric circuit problems and other small calculations which must be performed many times. In all these cases the mathematics is simple. Sometimes we have to look up data from charts or in tabular form, but this is something we can teach the machine to do. Certainly one way to find out how computers aid us is by making use of them to speed up and improve the engineering calculations we are now doing every day.

BETTER METHODS OF SOLVING PROBLEMS

FOR AN EXAMPLE of how some electrical utility companies are branching out into the application of automatic digital computers to engineering problems now being done with other tools, let us turn to what would normally be a-c network analyzer applications. Many years ago, before digital computers had advanced to the point of being even semiautomatic, some forward-looking electrical engineers were foreseeing the possibility of carrying out system-load flow studies by digital means. Techniques which seem crude now in view of our present equipment were developed. Naturally, time comparison and economic comparison with existing network analyzer techniques were not very favorable, but with the continued development of the high-speed automatic computer, digital methods now look very promising. You will hear more about this type of study as well as the use of these computers in the solution of short-circuit studies with complex impedances.

The digital computer has been used commonly in the determination of loss formula coefficients. These coefficients substituted into a loss formula allow us to predict the kilowatt I^2R loss in a power system for a given configuration of system loads and system generations. Used in conjunction with incremental fuel cost data, schedules may be drawn up to allow the dispatcher to operate his system most economically at all times.

Calculation of the coefficients depends on a knowledge of various characteristic impedances of the power system. In the past, these impedances have been found by setting up a model of the system on the a-c network analyzer and making a number of measurements. Now programs are available which make it a simple matter to obtain them digitally.

Attention also is being given to the digital calculation of swing curves previously carried out with the network analyzer and swing curve calculator. Some transient problems previously done on transient analyzers or differential analyzers are now being programmed for digital computers and are showing up well both timewise and economically. Examples of this are a study of conditions during emergency throwover of auxiliary equipment in a central station, and a study of the problems associated with the rapid shutdown of a nuclear power plant.

It may seem odd to look for a new way to solve a problem which is already being done very satisfactorily by standard and well-known techniques. But, in view of the tremendous potentialities of the digital computer, we can hardly afford to overlook the possibility that they may eventually offer us a tremendous advantage with these familiar problems.

SOLUTION OF NEW PROBLEMS

So far this discussion has been concerned chiefly with the type of engineering calculations which had to be done some way whether digital computers were available or not. Let us now take a look at a vast new field of problems—problems we would never have done if it had not been for the automatic digital computer. These are not problems we could not have done; the human being can do anything which the digital computer can do, only slower. These are problems which could not be justified economically if we had to do them by the old techniques. We could not have justified the cost of a study to determine shaft critical speeds in all multiunit turbine generator sets, nor the calculations necessary for the complete analysis of a steam piping system. There would not have been enough savings to justify system loss studies if they had to be done manually. Many of the problems arising in the new field of operations research can only be useful because digital computers are available to carry out the tremendous number of calculations necessary for their solution. These and many other problems which we have not even thought of yet will bring home to the electrical utility engineer the tremendous power and value of the automatic computer.

HOW TO GET STARTED

There is no better way to find out what computers will do for you than to get out and learn to use them. More and more, digital computers—small, medium size, and large—are available on a fee basis at the service bureaus of computer manufacturers and at other computing centers. Personnel are available to help the neophyte learn the ropes. Educational facilities are also available from computer manufacturers, from some universities, and from other sources. Start now to train your personnel to recognize that digital computers can be of value to them in the solution of their day-by-day engineering problems. When the time comes that you think your organization can justify a computer for this sort of use, you already will have built up a backlog of problems whose solution by digital computers is familiar to you.

Signal Corps Microfilms Engineering Drawings

Microfilm "windows" in tabulating cards, used for transmitting engineering drawings, are expected to save nearly a half million dollars annually in the U. S. Army Signal Corps procurement program. Special machines built by the Recordak Corporation are used in the microfilming process.

Over 300,000 engineering drawings have been microfilmed at Fort Monmouth, N. J. Positive film prints made from the original microfilm negatives, are being mounted in the tabulating aperture cards. They will be distributed to various Signal Corps installations for reference in repair and overhaul of signal equipment and for procurement purposes. They will be used to make reduced size paper prints to use in issuing bids to industry. The new system replaces the old costly method of making full-size paper reproductions of drawings. Most Signal Corps drawings, some dating back to World War I, have been converted to microfilm images the size of a match pad.

Eye Protection in Radar Fields

W. G. EGAN

Tests on animals indicate that eyes exposed to microwave radiation may develop cataracts. The design of protective goggles, utilizing transparent microwave shielding, is discussed.

MANY TYPES of electronic equipment are susceptible to interference from microwave fields resulting from rectification effects at the input of electrometer tubes or d-c amplifiers or from multivibrator triggering. Frequently a meter window in the equipment permits easy entry of the radar waves. It is desirable to prevent this entry by means of an optically transparent material which is opaque to microwaves.

Such material could be used in protective goggles to protect the eyes of personnel subjected to radar fields since it is known that microwave fields can produce cataract of the eye in dogs[1] and rabbits.[2,3] Further work[4,5,6] emphasizes caution when exposing the eyes to microwave radiation. The use of copper or bronze screen wire has been suggested as a protective measure[7]. This personnel hazard becomes particularly important where close contact with high-power radars exists as on ships, test facilities, tanks, aircraft, and from forward scatter propagation transmitters.[8,9]

OPTICAL AND MICROWAVE PROPERTY MEASUREMENTS

MEASUREMENTS WERE MADE of the optical and microwave properties of various materials. The optical property, measured with a spectrophotometer, was the per-cent transmission of visible light corrected for visual response. The microwave property was the per-cent transmission of three microwave frequencies (5.9, 9.7, and 18.8 kmc), measured by determining the insertion loss when the material being investigated was inserted between the coupling flanges of two wave guide sections. The test flanges were located just prior to a tuner section terminated in a tuned bolometer section, with both sections adjusted to make the voltage standing-wave ratio unity. The power absorbed by the bolometer was measured at 1,000 cps by a Hewlett-Packard model *415A* bolometer bridge unit. A 1,000-cps modulated klystron produced the microwave power, which was fed through an attenuator section, an absorption wave meter, and a slotted line, with the flange on the load side being used for tests. The TE_{10} mode was used for all measurements. Wave guide types *RG-50/U*, *RG-51/U*, and *RG-56/U* were used for frequencies of 5.9, 9.7, and 18.8 kmc respectively.

The results of the measurements are shown in Table I. As expected, good electrical conductivity is essential to microwave shielding, whereas this characteristic is not generally compatible with high light transmission and other psychological and physiological factors to be considered in the application to protective goggles. Table I also shows that the microwave results are rather critically dependent on frequency and the thickness of the material used. At the higher frequencies, the shielding effects of the film coatings are generally better. The greater the film thickness, the better the shielding because the film conductivity is greater. In general, thin films do not have the same volume resistivity or the same shielding properties as the bulk metal because of surface effects. It should be noted that the microwave attenuation is the result of both reflection and absorption of microwave energy by the various materials. Thus, the attenuation measured is, in part, a function of the mismatch between the impedance of the wave guide (Table I, last line) and the surface impedance of the conducting film. The d-c values of the surface film resistivity are specified as a guide to judging the relation to reflection properties. Inasmuch as the intrinsic impedance of free space is 377 ohms, the attenuation of the various materials in free space will be comparable with the values given in Table I.

CONSTRUCTION OF PROTECTIVE GOGGLES

IN CONSTRUCTING PROTECTIVE GOGGLES, the frame of the lenses must be such as to be nonresonant in the range of required effectiveness. Wire mesh has a limited microwave attenuation and causes a bad optical effect in front of the eyes. Also, the attenuation is poorer at higher frequencies. Lead glass used for X-ray protection has low microwave attenuation. The Corning heating panel glass did not permit clear vision because of the unevenness of the surface, although its microwave shielding and measured optical transmittance were favorable. The most feasible method found was the use of an evaporated gold film. Transmittance curves for two gold films are shown in Fig. 1. A pair of suitable goggles would have the gold film on the lenses and protective wire mesh on the sides. The 3.2 per-cent transmission is not too low for outdoor work and is permissible for indoor work in well-lighted rooms, provided the greenish-blue tinge of the gold film can be tolerated.

For particular instrumental applications where visual acuity is less important, wire mesh or the Corning heating panel glass may be more suitable.

Various types of semiconductive plastics were considered,[10,11,12,13] but the transparent plastics had extremely low conductivity, whereas the good conductors were not

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transparent. Various types of undercured plastics are conductive, but most are unstable and usually opaque. Where conductivity in plastics is produced by an additive, the transparency is, in general, adversely affected. The type of shielding to be used depends upon the application. The use of an evaporated gold film for radar protective goggles appears to be a feasible method of applying attenuation to lenses of various curvatures. The conductive coating on meter faces also serves as an antistatic coating.

Table I. Microwave and Optical Properties of Materials

Material	Microwave Transmittance, Per Cent at 5.9 kmc	at 9.7 kmc	at 18.8 kmc	Optical Transmittance, Per Cent
Gold film about 11 mμ thick on plastic (300 ohms per square)	23	10	0.8	49
Gold film about 30 mμ thick on plastic (12 ohms per square)	0.16	0.1	0.01	24
Gold film about 75 mμ thick on glass (1.5 ohms per square)	0.04	0.01	0.004	3.2
Copper mesh (20 per inch)	0.1	0.2	0.2	50
Copper mesh (8 per inch)	1.0	1.3	2.5	60
Lead glass (X-ray protective, ¼-inch thick)	30	25	16	85
Lucite (3/16-inch thick)	80	50	25	92
Libby-Owens-Ford Electrapane glass, with conductive coating about 150 mμ thick (120 ohms per square)	16	16	16	85
Libby-Owens-Ford Electrapane glass, with conductive coating about 300 mμ thick (70 ohms per square)	9	10	8	80
Corning heating panel glass, with conductive coating about 1.5 μ thick (15 ohms per square)	1.6	1.2	0.08	45
Waveguide impedance (ohms)	554	448	568	—

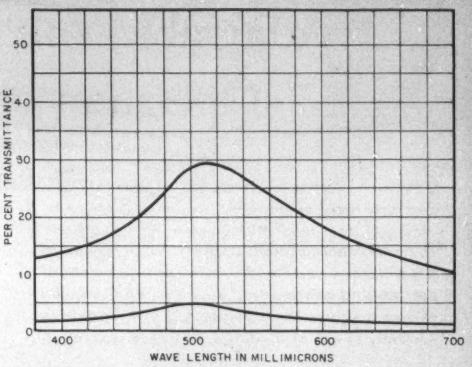

Fig. 1. Spectrophotometric curves. The upper curve is for 30mμ evaporated gold film on plastic, 24 per cent transmittance, corrected for visual response; the lower curve is for 75mμ evaporated gold film on glass spectacle lens, 3.2 per cent transmittance, corrected for visual response.

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Fuel Injection for Autos

Gasoline fuel injection for automobiles is an innovation that may well "revolutionize" the American car within the near future. The West German firm, Robert Bosch GmbH, has extensive experience in this field, having produced its 2,000,000th diesel fuel injection pump in Stuttgart last year. This fact indicates the fuel injection principle is a sound, efficient, and economical engine feature of the present and the future in the automotive transportation field. In the gasoline fuel injection system, individual cylinders are supplied with identical amounts of fuel, evenly and quickly. Gasoline from the tank goes to a pump, then is forced directly and evenly into the combustion chambers of the cylinders through tiny nozzles which are fed by tubes connected with the pump. The actual mixing of the fuel and air takes place in the combustion chamber. Thus, the clumsy carburetor is eliminated. Robert Bosch GmbH has adapted these injection systems for many years to such fields as passenger car gasoline engines, passenger car diesel engines, diesel trucks, diesel buses, tractors locomotive engines, marine engines, and utility engines.

Adjustable-Voltage Drive for the Operation of Ore Bridges

S. G. SMITH

The utilization of adjustable-voltage drives in ore bridges and unloaders provides a number of outstanding advantages. A description is given of two new machines employing this type drive currently in use at the McLouth Steel Corporation plant in Trenton, Mich.

THE ADVANTAGES of adjustable-voltage drive for ore bridges and unloaders have been provided in the operation of all drives, except turntable and rail clamps, on two new machines at the Trenton, Mich., plant of the McLouth Steel Corporation, Detroit, Mich. Novel features of each bridge include the use of adjustable-voltage control of bridge travel and apron hoist, and an electrical control system designed to save 15,000 pounds or 4,554 feet of trolley conductor. This saving was accomplished by reducing the previously required number of sliding conductors from 19 to 10 (Fig. 1). Each unloading bridge, however, still can be operated from the usual positions: operator's cab, bridge walkway, and apron hoist house.

Although adjustable-voltage drives have been used previously to some extent on Dravo Corporation ore bridges and unloaders for bucket close, bucket hold, and trolley drives, engineers decided it would be possible to extend their use with a minimum of equipment.

The McLouth unloading bridges (Fig. 2) were designed and built by Dravo Corporation to handle 12 gross tons of ore at the rate of 1,054 gross tons per hour. Each bridge has an over-all length of 545 feet, with 350 feet from centerline of pier leg to centerline of shear leg. The apron extending over the pier leg is hinged to permit raising it to clear the superstructure of lake carriers. Ore is transfered to a storage yard, approximately 777 by 350 feet, in which ore can be piled 70 feet high.

The new facilities are part of an expansion program of McLouth Steel Corporation that included the building of one new blast furnace, which requires a million tons per year of ore and limestone.

The power supply for the ore bridges is three phase, 60 cycles, 2,400 volts a-c, see Fig. 3. To supply 230 volts d-c constant potential would have required conversion from 2,400 volts a-c to 230 volts d-c. For this reason, the possibilities of using a complete adjustable-voltage system and gaining its advantages were investigated.

Adjustable-voltage drive uses a d-c shunt-wound motor to drive machinery with a separate d-c generator supplying power to the armature of the motor. By controlling the excitation and polarity of the generator field, the voltage applied to the motor armature can be varied; thus, the speed and direction of motor rotation can be controlled. A large amount of power in the armature loop circuit is controlled by a small amount of power in the generator shunt field. This is an advantage because it eliminates the need for large contactors and resistors in the motor armature circuit.

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ADDITIONAL ADVANTAGES

OTHER ADVANTAGES in using adjustable-voltage drives instead of constant potential are as follows:

1. Adjustable voltage completely bridges the gap between the 3-phase 60-cycle 2,400-volt a-c voltage supply and the 230-volt d-c driving motors.

2. Adjustable voltage obtains the economics of high-voltage a-c distribution along the ore yard.

3. During acceleration and deceleration, constant torque can be provided on an adjustable-voltage drive. If the torque limit is set to 150 per cent of the motor's self-ventilated 1-hour rated torque, then the maximum torque imposed on the cables and gears will not exceed 150 per cent. To obtain the same average rate of acceleration with a constant-potential drive, the necessary peaks would be 200 or 225 per cent of the motor rating. Gears must be selected to take care of the peak torques and may be heavier and more expensive when the peak torques are higher.

4. In many cases it is possible to use a smaller frame size motor with adjustable voltage than is the case with constant-potential operation. Shunt-wound mill motors rated at 230 volts can be operated with approximately 420 volts applied to the armature at rated current. As the speed of the motor is approximately proportional to the armature voltage, a given size motor can be used to operate at a higher speed and higher horsepower output than the name plate rating for 230 volts. The higher speed also gives a self-ventilated motor the ability to handle an increase in rms current, because of the additional ventilation that results from operating at the higher speed.

A good example of using a smaller motor was found when the apron hoist motor was selected. With adjustable voltage, a mill-type motor, Frame No. *AISE-606*, rated 31½ hp, 1 hour, 650 rpm at 230 volts d-c was selected. To this motor was applied 430 volts; thus, the rating changed

from 31½ hp to approximately 59 hp, or an increase of 87 per cent. To select a 230-volt d-c motor to operate on constant potential would mean the rating would have to be near the 59 hp obtainable with adjustable voltage. A mill-type motor, Frame No. *AISE-610*, is rated 62½ hp, 1 hour, 460 rpm at 230 volts d-c. This motor costs approximately 30 per cent more than Frame No. *AISE-606* and would result in a weight increase of 1,050 pounds. In addition, along with the smaller frame motors, it often is possible to use smaller brakes with the adjustable-voltage system.

With an adjustable-voltage drive, the load division between "hold" and "close" line motors during hoisting can be adjusted by means of the regulator. This makes it possible for the close line motor to take the same or a little more load than the hold line motor, thereby keeping the bucket jaws tightly closed. During lowering, a speed-matching circuit can be arranged to accelerate and decelerate both motors at the same rate so that there will be no tendency for the bucket to close. Both master switches must be on the same speed points in order for this arrangement to operate properly. This provides for better performance and better control of the bucket.

Adjustable voltage permits economical operation because it practically eliminates the power loss in series resistors during acceleration, thus saving power consumption per ton of material handled. Also, the physical dimensions and weight of the trolley can be decreased because smaller motors and brakes require smaller control panels. In addition, a large bank of power resistors is eliminated, and heavy power contactors are not necessary. The saving in weight of the trolley is also reflected in the design of the trolley runway and apron. Possible use of a larger bucket is another consideration.

With adjustable-voltage drive, there is less maintenance required for the electric and mechanical equipment that otherwise would be necessary due to torque limit. Smooth rapid acceleration and absence of excessive peak loads, along with excellent maneuverability, help keep maintenance costs to a minimum.

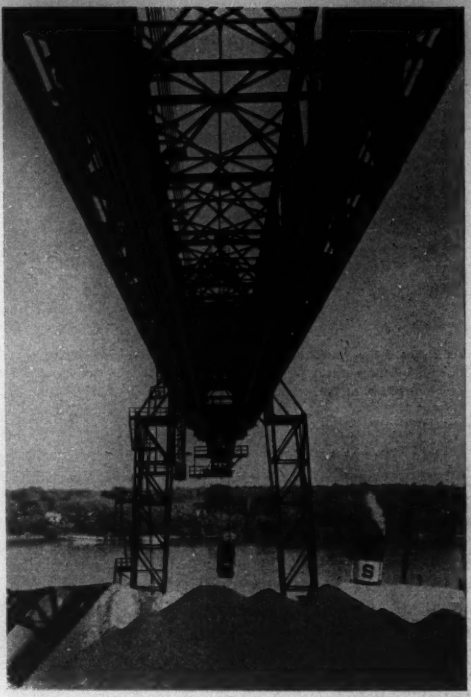

Fig. 1. The number of sliding conductors for this type bridge with adjustable-voltage drives was reduced from 19 to 10, saving 15,000 pounds of conductor material.

TROLLEY CONDUCTORS A PROBLEM

One of the principal problems in using adjustable-voltage drive is the number of trolley conductors. Ordinarily, several more conductors are required in an adjustable-voltage system than in a constant-potential system. This is so because the motor–generator set and its control, used in connection with the hoist and trolley motions, are too large and heavy to be mounted in the trolley control house. The motor–generator set is provided with an enclosure of its own not only for the set, but also for auxiliary equipment that is used in connection with its control. This house is mounted on the bridge structure and a means must be provided to bridge the electric gap between generator set and the trolley. The only way this gap can be closed is through the trolley conductors.

Dravo engineers concluded that all the advantages of adjustable voltage could still be obtained and even extended to the bridge travel and apron hoist, without adding extra weight, simply by using conductors for more than one purpose.

The elimination of nine conductors was accomplished in groups of three after analyzing the method of operation, the functions to be performed in the operator's cab, and those to be performed on the bridge walkway. As on most bridges, controls are required at both locations. The fact that the bucket close, hold, trolley, and turntable operation need to be controlled only from the operator's cab simplified the problem. Two control positions were required, however, for the bridge travel (operator's cab and walkway) and the apron hoist (apron hoist house and bridge walkway).

The first attack on the problem was to eliminate three trolley conductors by using d-c power on the trolley. The lights, operator's cab heater, and power to drive the rotating regulator could be operated from direct current as well as alternating current. The lights and operator's cab heater work just as efficiently from direct current as from alternating current. The rotating regulator is simply a small motor–generator set and the generator can be driven just as effectively by a d-c motor as an a-c motor.

Second, three more trolley conductors were eliminated

Fig. 2. These two combination ore bridge–unloaders feature the use of adjustable-voltage drives for nearly all operations. Each can handle 12 gross tons of ore at 1,054 tons per hour.

Fig. 3. A section of the motor–generator set supplying adjustable voltage to operate the bridge is shown at the right in this view of the machinery house interior.

by using a common return for the four generators that supply power to the trolley, close, hold, and constant-potential equipment. The size of this common conductor was reduced by connecting it to the minus side of the hold generator when hoisting, to the plus side of the close generator when hoisting, to the plus side of the trolley generator when traveling in, and to the negative side of the constant-potential generator.

A further reduction was sought in a common operation between trolley and bridge. It was found that there would be times when the bridge travel would be operated from the trolley or bridge walkway, but there would be no advantage to being able to move the trolley during bridge travel. Therefore, the trolley generator could be used to serve both the trolley movement and the bridge travel. This required merely a transfer of control from trolley to bridge movement. While doing this, the trolley master switch could be used for two purposes: as a trolley master and as a bridge master. Thus, two master switches could be eliminated, one normally used to control the pier leg truck motors and the other to control the shear leg truck motors. This changeover is performed in the operator's cab by means of a 4-point selector switch marked "Trolley–Both Ends–Pier End–Shear End." When the selector switch is set on "Trolley," any connection between trolley and bridge is broken and the master switch is used for trolley operation only.

Conventionally, a bridge is operated from the operator's cab by means of two master switches, one for the pier end and one for the shear end of the bridge. Thus, it is possible to operate the bridge ends independently or simultaneously. Such operation normally requires four trolley conductors. Three of these conductors were eliminated on the McLouth ore bridge leaving only one between trolley and bridge.

UNIQUE ELECTRICAL CIRCUIT

THE ELIMINATION of these three conductors and use of one collector to perform three functions is unique in its operation. The system consists of the 4-point selector switch, four Rectox rectifier units, and two relays that operate on half-wave rectified 60-cycle voltage. Two rectifiers are mounted on a panel in the trolley machinery house. The two relays and the other two rectifier units are mounted on a panel in the motor–generator machinery house. The power supply is 220 volts, 60 cycles a-c. One collector is required between bridge and trolley. The common collector is in the other side of the a-c line. Fig. 4 shows the system.

With the selector switch set on "Trolley" the operation is conventional, and the contactors of the switch are open. Thus, relays *PCR* and *SCR* cannot be energized.

When the selector switch is set on "Both Ends," the

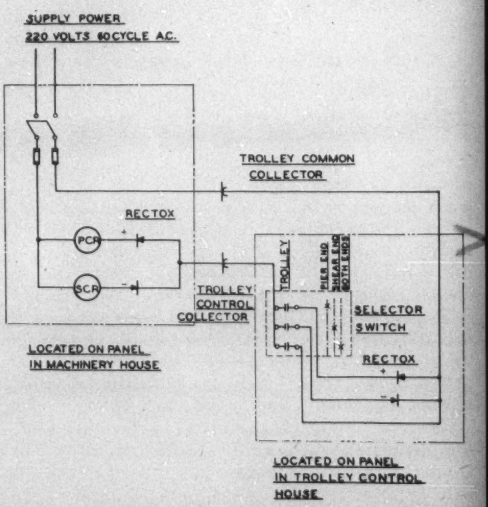

Fig. 4. Pier and shear leg control circuit permits operating each independently or together through a 4-position selector switch and common conductor, using double rectification of a-c power for circuit selection.

trolley master switch operates as a bridge master. Any movement of this master causes both ends of the bridge to move simultaneously. When the selector switch is set this way, one side of the a-c line passes from the bridge through the common collector to the trolley and through the selector switch back to the bridge by means of the trolley conductor. This completes the circuit to operate both the pier (*PCR*) and shear (*SCR*) leg relays.

When the selector switch is set on "Pier Ends," the a-c circuit is completed through a rectifier between the common collector and trolley collector. This permits a half-wave rectified voltage to pass through the selector switch, and back to the bridge by means of the trolley conductor. This rectified voltage feeds two rectifiers in parallel circuits, one with a relay for the pier leg and the other with a relay for the shear leg. The shear-end rectifier opposes the rectified voltage so that the relay in series with it is not energized. Only the pier-end relay is energized, so that the circuit is set up to permit the master switch to become a pier-end bridge master switch.

When the selector switch is set on "Shear End," the same type of circuit is set up with the reverse half-wave rectified voltage, which can energize only the shear-end relay.

This elimination of 7½ tons of trolley conductor and other electric equipment has resulted in substantial savings both in the construction of the ore bridge and in its use, without sacrificing operating convenience and speed.

Plant Mortality

J. F. BRENNAN

Methods currently being used for determining equipment life require extensive research and analyses, much of which cannot readily be adapted to solution on electronic computers. The proposed method, based upon the use of a parabolic frequency distribution of failures, eliminates most of the research and provides for solution on either desk calculators or digital machines.

PROBLEMS IN ENGINEERING ECONOMICS usually require an estimate of the average life expectancy of equipment. Past experience is a guide in forecasting life, but as technological progress cannot be predicted with great accuracy, it may be wasteful to spend much time and money on the accumulation of data solely for the purpose of applying actuarial methods in the study of equipment life. Furthermore, the variability of past experience data may not justify extensive analysis for this purpose.

There is proposed herein a method simpler of application than most other techniques currently employed in life analyses. The simplification is achieved by the use of a parabolic frequency distribution of failures. This permits the employment, as raw data, of the readily available accounting record of yearly additions and failures (retirements) expressed as dollars or units. The failures are taken as reported yearly, without segregation as to age at time of failure.

A special article recommended for publication by the AIEE Committee on Power Generation.

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The accuracy of the method is still acceptable when applied to data whose frequency distribution of failures diverges from the assumed form, provided the divergence is not extreme.

DEVELOPMENT OF METHOD

LET THE FREQUENCY DENSITY FUNCTION of failures be defined by

$$f(x)\Delta x = (ax + bx^2)\Delta x \qquad (1)$$

where x is the age at time of failure, $f(x)\ \Delta x$ is the fraction of plant failing between ages x and $x + \Delta x$, and $f(x)$ satisfies the conditions

$$f(0) = f(\omega) = 0 \text{ and}$$

$$\int_0^{\omega} f(x)dx = 1,$$

where ω is the maximum life.

These conditions, applied in equation 1, lead to

$$f(x) = ax + bx^2 = \frac{6}{\omega}\left[\left(\frac{x}{\omega}\right) - \left(\frac{x}{\omega}\right)^2\right] = ax - \frac{a^{3/2}}{\sqrt{6}}x^2 \qquad (2)$$

Consider now the failures in year k from the installations A_t made in year t. Their average age will be $(k - t + \frac{1}{2})$ years and, applying equation 1, we may express the number of failures as

$$A_t f\ (k - t + \tfrac{1}{2}) = A_t\left[a\,(k - t + \tfrac{1}{2}) + b\,(k - t + \tfrac{1}{2})^2\right] \qquad (3)$$

where

$$a = \frac{6}{\omega^2} \text{ and } b = -\frac{6}{\omega^3}$$

The total failures F_k in year k will be the sum of those failing at all ages, from all plant previously placed; that is

$$F_k = \sum_{t=1}^{k} A_t \left[a(k - t + \tfrac{1}{2}) + b(k - t + \tfrac{1}{2})^2 \right] \quad (4)$$

The total failures of year $(k - 1)$ may be written

$$F_{(k-1)} = \sum_{t=1}^{k-1} A_t \left[a(k - t - \tfrac{1}{2}) + b(k - t - \tfrac{1}{2})^2 \right] \quad (5)$$

Expanding equations 4 and 5 and taking the difference we find

$$F_k - F_{(k-1)} = \Delta F_k = a \left[\sum_{t=1}^{k-1} A_t + \tfrac{1}{2} A_k \right] + b \left[\tfrac{1}{4} A_k + 2k \sum_{t=1}^{k-1} A_t - 2 \sum_{t=1}^{k-1} A_t t \right] \quad (6)$$

With the notation

$$U_k = \sum_{t=1}^{k-1} A_t + \tfrac{1}{2} A_k$$
$$V_k = \tfrac{1}{4} A_k + 2k \sum_{t=1}^{k-1} A_t - 2 \sum_{t=1}^{k-1} A_t t \quad (7)$$

Equation 6 may be written

$$\Delta F_k = aU_k - \frac{a^{3/2}}{\sqrt{6}} V_k \quad (8)$$

From equation 8 it is seen that the data of each year give an estimate of a. The least squares estimate is given by

$$\frac{d}{da} \sum \left(aU - \frac{a^{3/2}}{\sqrt{6}} V - \Delta F \right)^2 = 0 \quad (9)$$

Performing the differentiation and collecting terms we have

$$a \sum_k U^2 - \frac{5a^{3/2}}{2\sqrt{6}} \sum_k UV - \sum_k (\Delta F)U + \frac{3a^{1/2}}{2\sqrt{6}} \sum_k (\Delta F)V + \frac{a^2}{4} \sum_k V^2 = 0 \quad (10)$$

which is a biquadratic equation in $m = \sqrt{a}$; that is,

$$c_4 m^4 - c_3 m^3 + c_2 m^2 + c_1 m - c_0 = 0$$

This equation can be solved readily by Horner's method, or a satisfactory graphical solution can be made by plotting and finding the point of intersection of

$$\phi(m) = c_0 - c_1 m$$
$$\Theta(m) = m^2 (c_2 - c_3 m + c_4 m^2)$$

With a estimated, the survivor ratio curve may be derived from equation 2. For unit radix, the survivor ratio at age x is one less the total of retirements from 0 to x. That is,

$$y(x) = 1 - \int_0^x f(x)dx = 1 - \frac{a}{2} x^2 + \frac{a^{3/2}}{3\sqrt{6}} x^3 \quad (11)$$

Other statistics of interest are estimated as follows:

$$\text{Mean life } \bar{x} = \int_0^\omega xf(x)dx = \frac{\omega}{2} = \frac{1}{2}\sqrt{\frac{6}{a}} \quad (12)$$

$$\text{Variance of mean life } \sigma_{\bar{x}}^2 = \frac{1}{N} \int_0^\omega (x - \bar{x})^2 f(x)dx = \frac{3}{10a} \quad (13)$$

$$\text{Relative dispersion} = \frac{\sigma}{\bar{x}} = 0.447 \quad (14)$$

$$\text{Life expectancy at age } h \quad E_h = \frac{1}{y(h)} \int_h^\omega y(x)dx \quad (15)$$

Sinking fund depreciation annuity rates are readily derived from equation 11.

TESTS

VARIOUS TESTS were designed to determine how close an approximation this method will give for plant data having a known mean life, but with failure dispersion patterns differing from the assumed parabolic form. Of these tests, we will cite three in which "synthetic" data were first built up from given frequency curves. For all three tests, the same set of plant installations was used. These installations were assumed to be 1,000 units in the first year and random numbers between 100 and 300 for succeeding years. Failures were then calculated to follow three separate curves[1] all giving a known mean life of 5.00 years. The curves are described as the S2 symmetrical curve, the R2 right modal (negative skewness), and the L2 left modal (positive skewness) curve.

The plant installations and the computed failures are

Year	Plant Installed	Failures S2 Curve	Failures R2 Curve	Failures L2 Curve
1	1000	1	27	8
2	103	22	51	44
3	284	85	92	127
4	285	183	154	221
5	142	274	232	260
6	143	324	303	266
7	104	318	320	259
8	169	266	275	239
9	290	213	220	212
10	292	176	195	195
11	253	170	181	194

The method described was then applied to these data and the coefficients of a and its powers, as shown in equation 10, were computed. The roots were located by the graphic process described. The derived mean lives are

Case	Estimated Mean Life	Error, Per Cent of True $\bar{x}$
S2	4.92	1.60
R2	5.02	.40
L2	5.19	3.80

These results are well within the tolerances of practical applications.

APPLICATION TO WATT-HOUR METERS

AN APPLICATION of this method to electric watt-hour meter data yielded a mean life of 26.1 years. The raw data, from the accounting records of a large electrical

utility, consist of a list of additions and retirements, in dollars, for years 1920 through 1953, as shown in Table I. For the plant balance at the beginning of year 1920, the average age was estimated and the amount, adjusted to give the estimated failures shown for years 1910 through 1919, was set back to 1909 and considered as an addition in that year.

The information on Table I was processed in an IBM *604* machine. The numerical values of U and V, as defined in equations 7, were derived for each year, as were the squares and cross-products needed for equation 10. In order to smooth out the failure data, 5-year moving averages were first computed and these were used in the determination of U, V, etc.

For this application the experience of the 5-year "band" 1946-1950 was employed by taking for the k limits in the summations of equation 10 the t values for 1946 through 1950. (In this case the t's were the actual years less 1900.)

Table I. Watt-Hour Meters

Year	Gross Additions in dollars (000's omitted)	Failures (Retirements) in dollars (000's omitted)
1909	5,601	
1910		67.20
11		66.39
12		65.59
13		64.81
14		64.03
1915		63.26
16		62.50
17		61.75
18		61.01
19		60.28
1920	418	17.72
21	585	42.38
22	601	46.90
23	742	49.74
24	773	65.39
1925	691	57.97
26	748	90.53
27	645	110.57
28	572	108.75
29	554	156.62
1930	557	124.61
31	579	218.71
32	304	156.48
33	169	126.11
34	239	92.07
1935	346	92.41
36	531	102.33
37	557	198.34
38	417	278.13
39	769	245.07
1940	739	251.26
41	820	172.83
42	408	101.27
43	330	114.02
44	444	172.74
1945	822	144.86
46	908	119.56
47	2,011	78.72
48	2,947	90.16
49	1,752	195.56
1950	1,968	324.41
51	2,803	398.00
52	2,168	364.53
53	2,285	569.05

The watt-hour meter data led to the equations

$$\phi(m) = 3.99665 - 87.3746\ m$$

$$\Theta(m) = m^2(3017.254 - 113{,}480.31\ m + 1{,}026{,}585\ m^2)$$

These were plotted and the intersection read as $m = 0.04693$ ($m = \sqrt{a}$). The mean life was calculated by use of equation 12 as

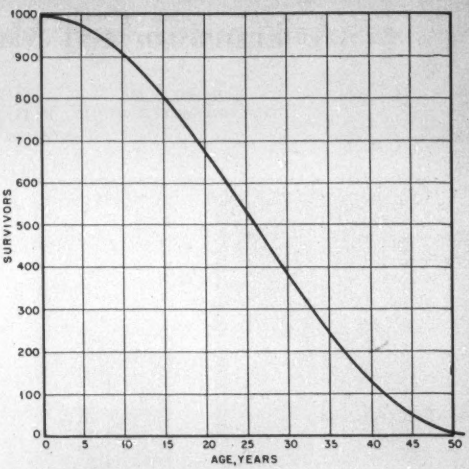

Fig. 1. Mortality curve for watt-hour meters, based on experience of 1946-50, inclusive. Mean life: 26.1 years.

$$\bar{x} = \frac{1}{2}\sqrt{\frac{6}{a}} = \frac{\sqrt{6}}{2m} = 26.103 \text{ years.}$$

The survivor curve equation, 11, becomes

$$y(x) = 1 - 0.001101\ x^2 + 0.000014065\ x^3$$

As a check, the mean life may be computed from the survivor equation. It is convenient to express the equation in terms of a radix of 1,000 units by multiplying through by 1,000. The maximum life ω is found by solving $y(\omega) = 0$. The mean is then

$$\bar{x} = \frac{1}{1{,}000}\int_0^{52.2} y(x)dx = 1{,}000\ x - 0.36707\ x^3 + 0.003516\ x^4 \Big|_0^{52.2}$$

$$\bar{x} = 26.1 \text{ years.}$$

Fig. 1 shows the survivor curve with 1,000 radix.

One great advantage of this method is that once the data are processed and the summations derived, solutions can be made quickly for any chosen band or combination of bands of years; thus, changing mortality patterns can readily be detected. A further advantage is that after IBM printed "runs" are made, new yearly data may be appended and new summations derived on desk calculators.

The method will not give reliable results if applied to equipment and structures in which no failures ordinarily occur in the early years of life, e.g., transmission towers. It has proved quite satisfactory for such classes of plant as meters, line transformers, overhead conductors, electrical services, and other types of plant involving fairly large numbers of similar items.

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A Transistorized Multiplex Telegraph Set

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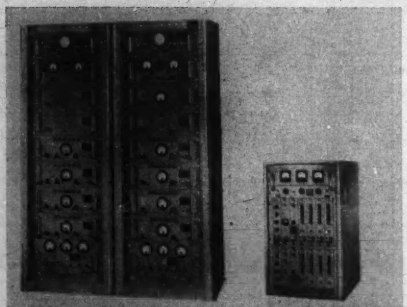

	ELECTRONIC MULTIPLEX AN/FGC-5	TRANSISTORIZED MULTIPLEX AN/UGC-1(XN-0
VOLUME	55 CU FT	11 CU FT
WEIGHT	1450 LBS	275 LBS
POWER INPUT	1400 WATTS	75 WATTS
TRANSISTORS	0	572
TUBES	357	0
GERMANIUM DIODES	33	739

Fig. 1. Comparison data, telegraph terminal sets.

INCREASED USAGE of radio teletypewriter communication has widened the demand for facilities for multiplexing teletypwriter channels on a single radio circuit, for economy of frequency spectrum and equipment. Many of the potential applications of multiplex require smaller and lighter equipment than heretofore available, with unusually high reliability. The developmental transistorized 4-channel time division multiplex equipment designed to meet this potential demand is functionally similar to, and compatible with, the *AN/FGC-5* electronic multiplex, which has been in general use since 1950 on long-haul high-frequency radio circuits. In all active electronic functions such as switching and amplification, as well as in the power supply, only solid-state devices are employed. There are no vacuum tubes in the set. This equipment is designed to be an integral part of a time division multiplex system wherein two, three, or four start–stop telegraph channels are combined for transmission over a common communication circuit.

Time-division multiplexing of telegraph circuits is not new, dating back to before the turn of the century. The early multiplex sets were all mechanical units. These equipments were succeeded by electromechanical systems, which in turn were replaced by the electronic multiplex in general use today. Over 500 of the vacuum-tube sets are presently in service throughout the world.

As the result of new design requirements for a multiplex set of minimum size, weight, and power consumption, the transistorized multiplex was designed. Four developmental models have been constructed and are currently undergoing field trials. Fig. 1 shows comparison data between the transistorized and the electronic multiplex.

Both point-contact and junction transistors are employed. Characteristics of point-contact transistors, which enable the realization of emitter-to-collector current gains higher than unity, greatly simplify the design of certain of the circuits.

Among the several basic circuits employed to accomplish the necessary switching and logic functions is the ring distributor. A point-contact transistor is utilized to accomplish the necessary sequential switching function because of the basic circuit simplicity thereby achieved. Slightly over three components per stage, in addition to the transistor, are all that are required. In addition to its basic distributor function, the ring distributor is employed in the equipment as a frequency divider. There are a total of 21 separate ring distributors in the equipment, each containing three to seven stages.

In addition to the distribution of intelligence, information must be stored in binary form. This binary storage of information is accomplished by the use of Eccles-Jordan p-n-p junction transistor flip flops. Certain switching and timing functions are also accomplished through the use of circuits of this type.

Extreme miniaturization was not the primary objective in packaging the equipment, although a significant reduction in weight and size was achieved. Reliability and serviceability were considered of primary importance, but consistent with these, miniaturization was desired. All circuit elements are mounted on etched cards, and are spaced conservatively.

The transistor multiplex, while still in the developmental stage, has shown promise of providing extremely high reliability in operating service. Transistor and component failures traceable to circuit operation have been almost nonexistent. Future field and laboratory tests should provide additional information which will permit more accurate prediction of the ultimate reliability to be expected of the equipment.

Application of solid-state devices to the multiplexing function, enabling the reduction of volume and power requirements, should provide new applications for the transistor multiplex. What is most important, however, is that the expected long life of transistors should provide a degree of reliability up to this time unobtainable in electronic communication equipment.

Digest of paper 56-987, "A Transistorized Time-Division Multiplex Telegraph Set," recommended by the AIEE Committee on Telegraph Systems and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 1-5, 1956. Scheduled for publication in AIEE *Communication and Electronics*, 1956.

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Analog Computer Synthesis and Error Matrices

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AN ANALOG COMPUTER or differential analyzer programmed for a system of linear differential equations ideally exhibits solutions of the mathematical problem. Such performance necessarily can only be approximated, inasmuch as the networks in an electronic analog machine are far more complex than the mathematical problem equations to be solved imply.

In order to analyze so complex an electronic system as a computer systematically, matrix analysis is applied to determine more precisely the actual performance of the machine. Clearly, an analysis considering all physical parameters in the computer—while feasible and straightforward—is unnecessarily involved. This article, therefore, is constrained to approximations which predict the stability of the computer.

The basic electronic computer networks consist of multistage electronic amplifiers and primitive dinodes—that is, capacitors and conductances—or their combinations. These are analyzed and synthesized on a common-node co-ordinate basis, yielding admittance matrices which can be partitioned into ideal synthesis and error submatrices.

The analysis indicates that although the error magnitude terms can be minimized by increasing the electronic amplifier gains, the stability of the computing networks is nevertheless significantly influenced by the presence of these error terms, no matter how small.

As an example, consider the single nth order equation

$$(a_1 + a_2 d + \ldots + a_n d^{n-1} + a_{n+1} d^n)x = 0 \qquad (1)$$

where $d = d/dt$, which may be programmed in the following way

$$\begin{bmatrix} d & -1 & 0 & 0 & . & 0 & 0 \\ 0 & d & -1 & 0 & . & 0 & 0 \\ 0 & 0 & d & -1 & . & 0 & 0 \\ . & . & . & . & . & . & . \\ 0 & 0 & 0 & 0 & . & d & -1 \\ a_1 & a_2 & a_3 & a_4 & . & a_n & a_{n+1} \end{bmatrix} \cdot \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ . \\ x_n \\ x_{n+1} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \\ . \\ 0 \\ 0 \end{bmatrix} \qquad (2)$$

and synthesized on the computer according to the ideograph of Fig. 1.

The stability of differential equation 1 is represented by the character of the roots of the determinantal equation

$$a_1 + a_2\lambda + \ldots + a_n\lambda^{n-1} + a_{n+1}\lambda^n = \Delta(\lambda) = 0. \qquad (3)$$

The stability of the computing network, however, is determined not by equation 3 of the problem to be solved, but rather by the character of the roots of the determinantal equation for the complete electronic network including the amplifier characteristics. That is, by the determinant of the sum of the synthesis matrix, equation 2, and the corresponding computer error matrix, and reads

$$\Delta\left(\lambda + (\lambda+1)\frac{1}{\mu}\right) + \sum_{i=1}^{n+1} |a_i| \frac{1}{\mu}\left(\lambda + (\lambda+1)\frac{1}{\mu}\right)^n = 0 \qquad (4)$$

in which it should be noted that $\Delta(\ )$ is defined by equation 3.

Clearly, the number and character of the roots of equation 4 including the computer amplifier characteristics may deviate markedly from those of the original differential equation, given by equation 3. It follows that a mathematically stable system of differential equations can, nevertheless, lead to a completely unstable synthesis on an electronic computer.

To summarize, the application of matrix methods provides a powerful method of analysis of electronic analog computer networks. The matrix methods are completely general, and may be applied to the study of stability of computers, and to other problems such as the study of the best amplifier characteristics for computer applications, the effects of precision of network components, and the influence of stray parameters.

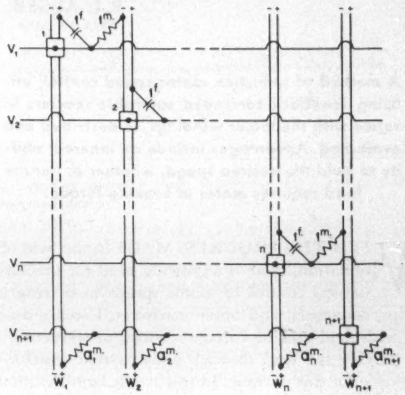

Fig. 1. Ideograph of synthesis network according to equation 2.

Digest of paper 56-49, recommended by the AIEE Committee on Basic Sciences and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Published in AIEE *Communication and Electronics*, March 1956, pp. 26-32.

P. M. Honnell is with Washington University, St. Louis, Mo., and R. E. Horn is with the Westinghouse Electric Corporation, Baltimore, Md.

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Speed Control of Induction Motors Using Saturable Reactors

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Y. H. KU
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A method of induction motor speed control, utilizing feedback-controlled saturable reactors in series with the motor windings, is described and evaluated. Advantages include an inherent ability to hold the desired speed, whether or not the load requires motor or braking torque.

WITH THE PROGRESS MADE in the field of automation, there is a growing need for precise and stepless control of motor speeds in driving fans, pumps, conveyors, and other machines. Usually d-c motors with field and/or voltage control, or induction motors driving the load through eddy current clutches are employed for this purpose. In this article, another method of induction motor speed control, consisting of the use of feedback-controlled saturable reactors in series with the motor windings is considered.

This method does not require a d-c power supply, or any commutators or power tubes. Besides an essentially standard induction motor, the scheme uses only readily available reactors and control circuits. The direct current required for the control is only 1 or 2% (per cent) of the motor rating, and can readily be supplied from amplistats, or equivalent devices, just as in the case of the clutch.

Calculated and test data are given, showing that this method of speed control allows the speed of a wound rotor induction motor to be set at any desired value between 100% forward and 100% backward, and to be held nearly constant at the set value, over a full range of torque from plus (motoring) to minus (braking), up to the maximum torque value. This speed control is accomplished by merely turning a small control knob.

This inherent ability to hold the desired speed, regardless of whether the load requires motoring or braking torque, makes the scheme especially suitable for bridges and hoists, and provides characteristics not attainable with eddy current clutch drive.

The speed of an induction motor can be maintained precisely at any desired value by placing saturable reactors in series with the motor windings and holding the direct current in the reactors (and, therefore, the motor voltage) at the appropriate value with a feedback control circuit. For small changes from full speed, and when the torque required at low speeds is relatively small, squirrel-cage motors may be used, with the reactors in the primary circuit. For large changes in speed, and when high torques at low speeds are required, wound-rotor motors with secondary resistors may be used. The reactors may be placed in either the primary or the secondary circuit. In the latter case, good performance can be obtained over a wide speed range by employing a secondary reactor–resistor network. When braking or reversed-torque operation is required, two independent primary windings with either the same or a different number of poles, controlled by independent reactors, may be used. By combinations of these schemes, with contactors to change the connections when needed, the speed–torque performance of a d-c shunt motor can be substantially duplicated, although the induction motor efficiency will usually be lower and its heating greater.

Revised text of paper 56-946, recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Fall General Meeting, Chicago, Ill., Oct. 1-5, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, Feb. 1957.

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PERFORMANCE CALCULATIONS

THE EQUIVALENT CIRCUIT of an induction machine is shown in Fig. 1. Note that the effective secondary (rotor) resistance R_r/s is not constant, but varies inversely with the slip s. This variation with s applies to all resistances in the rotor circuits. In Fig. 2, a saturable reactor is added in series with the primary (stator) circuit. In Fig. 3, a parallel network of a resistor and a saturable reactor is added in the rotor circuit. Fig. 2 represents the control circuit for a squirrel-cage motor, and Fig. 3 that for a wound-rotor motor. More complex networks may be used to advantage in some cases.

As a first approximation, the effect of the magnetizing reactance X_m may be neglected. With the magnetizing branch omitted, it makes no difference whether additional reactance is inserted in the stator or the rotor side of the equivalent circuit. However, it makes a lot of difference whether the external resistance is inserted in the stator or the rotor side. A series resistance R_e has a larger effective resistance R_e/s when it is connected in the rotor circuit. The motor torque in the per-unit system then becomes $I_2^2 (R_r + R_e)/s$, where I_2 denotes the rotor current, R_r the rotor resistance, and R_e the external resistance in the rotor circuit. The simplified equivalent circuit is shown in Fig. 4, where R_1 represents the total resistance in the stator circuit, and X_e the total external reactance in both the stator and rotor circuits.

Assuming a fixed value of applied voltage E, the voltage applied to the motor will be E minus the drop in the external reactance, jIX_e. The motor speed and torque may then be varied by changing the direct current in the

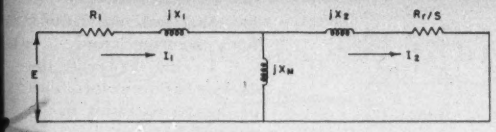

Fig. 1. Equivalent circuit of induction motor.

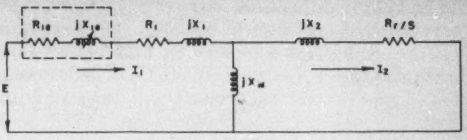

Fig. 2. Induction motor with saturable reactor in series with the primary circuit.

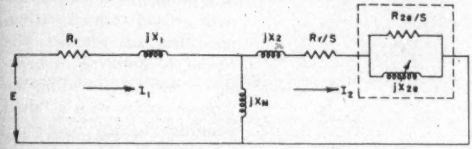

Fig. 3. Induction motor with saturable reactor in shunt with an external secondary impedance.

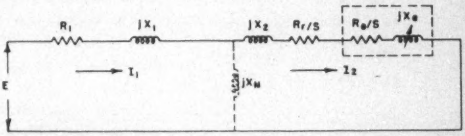

Fig. 4. Simplified equivalent circuit of induction motor with an external secondary impedance.

saturable reactors, thus changing X_e. A performance diagram can be constructed, Fig. 5, by plotting the effective rotor resistance, $R = (R_r + R_e)/s$ against the total reactance, $X = (X_1 + X_2 + X_e)$, for constant values of torque, and for constant current. Both of these sets of curves are circles. For a given torque, says 100% of the rated value, I^2R is known, and thence R is found for a chosen current value, say 110% of the rated value. With E, I, and R known, the circuit gives the corresponding value of X. If the speed is to be held at 97% of synchronous ($s = 0.03$), the necessary value of R_e is equal to $0.03R - R_r$. The control network must not only give the required value of R, but also it must provide a value of X_e that will make X satisfy the chosen current and torque values.

It will be noted that the 100% torque and 100% current circles do not intersect each other, since the addition of X_e has lowered the motor power factor. It is a matter of engineering judgment how much increase in the current to allow at full-load torque, and whether to restrict this increase by adding more resistance in the rotor circuit, or by saturating the external reactance more completely, or in some other way. When this allowable current is chosen, its circle intersects the circle for the desired torque at a pair of values R, X. Heating limits the allowable value of current at high torques, but at low torques there is a good deal of leeway to choose R and X values that will give the most economical design. For example, when it is desired to provide a torque of only one half the rated value or less at low speeds, it may be permissible merely to increase the reactance X_e until the current is reduced to the needed value, whereas to obtain a high torque at a low speed it is necessary to provide additional rotor circuit resistance.

ALTERNATIVE METHODS OF REACTOR SPEED CONTROL

IF A TYPICAL SINGLE-WINDING INDUCTION MOTOR with a low resistance secondary, driving a fan, is connected to the power system through saturable reactors, the speed–torque curves that can be obtained are as shown in Fig. 6. With the reactors fully saturated, the motor torque follows Curve A, with a high maximum torque and a very small full-load slip. If the external reactance is increased, the maximum torque of the motor falls, and the speed at which maximum torque occurs rises proportionately so that the speed at full-load torque decreases very little, as shown by Curve B. When the primary reactance is increased to such a high value that the maximum torque is less than the full-load torque, the motor speed falls rapidly, and the motor operates on the unstable side of the torque curve, as shown by Curve C.

Even though stable operation may be secured with this arrangement, by means of feedback control, the performance of the motor at low speeds will be unsatisfactory, because the reactors required for control are large, the motor power factor is always less than 0.7, and a highly educated circuit is required for accurate control of the speed. For these reasons, applications such as fan drives, which require very small slip at the highest torques, should have the control reactors placed in the secondary circuits.

However, the primary reactor control is quite suitable for such applications as bridges and hoists, which require high torques at low speeds and braking, and which can permit a slip of 10% or more at full-load torque. Of course, the efficiency of the system is always a little less than the ratio of the operating speed to synchronous speed, just as for any wound-rotor motor, so that the scheme is not suitable for applications requiring continuous operation at low speeds, unless the high power losses are permissible.

BRIDGE AND HOIST CONTROL

THE REQUIREMENTS for the motors to operate a bascule bridge (Fig. 7) are as follows:

1. In opening the bridge, the motor must start smoothly, whatever the ice and snow load, and come up to full speed in 5 or 10 seconds. The torque should be built up without shock, and 200% or more of rated

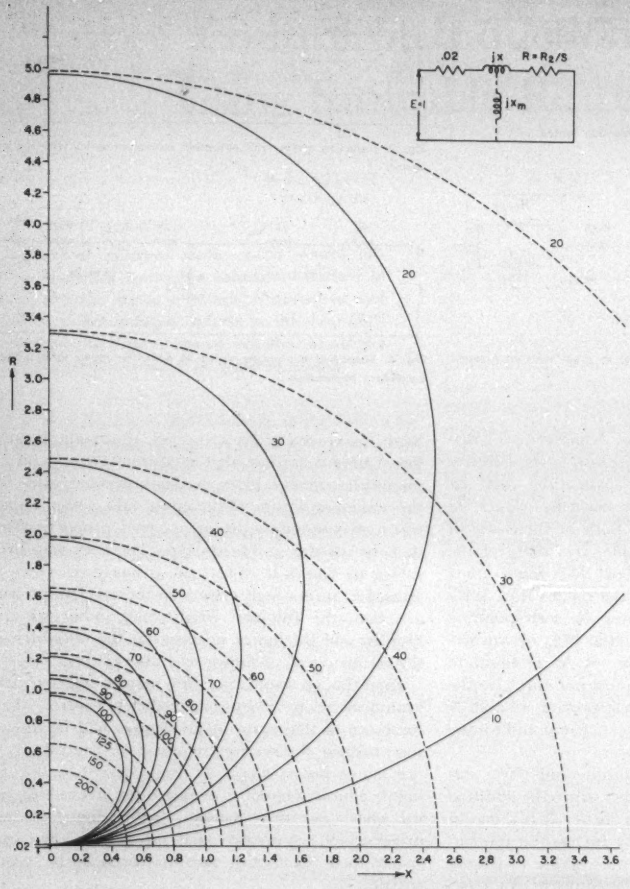

Fig. 5. Constant-torque and constant-current circle diagrams. Solid-line curves are for indicated percentage values of T. Dashed curves are for indicated percentage values of I.

torque should be available, thus giving rapid acceleration.

2. At full-load torque, the motor should run at 85 or 90% of synchronous speed, and it also should deliver 160% torque at 75 or 80% speed. Normally, the full-speed operation may continue for about 60 seconds, until the bridge has completed 85 or 90% of its travel.

3. During the last 10 or 15% of its travel, the motor should run at about 10% of synchronous speed, so that the bridge will come into its fully open position smoothly, and lock in without shock. During this period, each leaf of the bridge presents a large area to the wind, and the resulting load on the motors may exceed full-load torque. Therefore, to maintain the desired speed in a crosswind, the motor on one leaf of a two-leaf bridge may be required to exert 100% braking torque, while that on the other leaf may require 200% motoring torque.

4. To close the bridge, the same procedure is used with the motors operating in the reversed direction.

The essential requirement of holding about 10% speed with a fixed control setting, regardless of whether the torque is motoring or braking, is met by providing the 3-phase motor with a "dual winding" having two independent circuits with six leads brought out, as in the case of part-winding starting of squirrel-cage motors. The two half windings are connected to the power supply through independent sets of three single-phase saturable reactors, as shown in Fig. 8.

Four half-current contactors are provided for connecting each half winding to the power supply independently, with either forward or reverse rotation, as may be called for by the control. There are also two amplistats, one for each set of saturable reactors, to supply the d-c control current. To control the speed, the d-c voltage supplied by a tachometer on the shaft of the motor is matched against a reference voltage set by the control dial. The difference between the speed and reference voltages is applied to the amplistats, which deliver corresponding direct currents to the control windings of the two sets of reactors. The motor voltage and torque change accordingly, the change continuing until the speed voltage matches the reference voltage.

To provide for braking and reversing without losing control of the load, the control circuit is arranged so that whenever the motoring torque falls below about one quarter of rated value, the forward contactor on one of the half windings drops out, and the corresponding reverse contactor closes, putting the two half windings in operation with opposed directions of rotation. If still lower torque is required, the current in the reversed winding is built up, and that in the forward winding is reduced, until the torque reaches about 20% of rated value in the overhauling or braking direction. If still

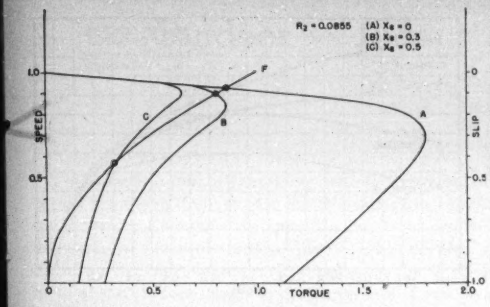

Fig. 6. Speed–torque curves for induction motor driving a fan with reactor speed control.

more braking torque is required, the forward contactor of the second half winding drops out, and this half winding is reconnected also in the reversed direction.

TEST RESULTS

A 4-POLE WOUND-ROTOR MOTOR of normal design, rated 25 hp, 220/440 volts, was tested in accordance with this scheme. Fig. 9 shows that when the control was set for 1,400 rpm, the motor delivered full-load motoring torque (73 foot-pounds) at a speed of 1,200 rpm, or an equal braking torque at 1,590 rpm. At maximum speed setting for 1,800 rpm, the speed drop from full-load braking to full-load motoring was 430 rpm, while at the 200 rpm setting the drop was 320 rpm. The shift from both windings motoring to opposed windings occurred at about 20% of full-load torque, and the shift from opposed-winding to both-winding braking occurred at about the same torque in the reversed direction.

It is interesting to note that the three phase currents in each of the half windings remained balanced under all conditions of operation, even when the two windings were operating in opposed directions of rotation. This is explained by the fact that the "through reactance," which limits the circulating currents transferring power between the several phases, is quite high, so that the two windings perform in nearly all respects as if they were two independent motors on the same shaft.

The tests were made with the motor windings in Y, instead of their normal delta connection, so that the rated voltage and current of the motor were 380 volts and 37 amperes, respectively. The secondary resistor was 0.30 ohm, or 0.30 per unit, taking the rotor current base to be 91 amperes, the equivalent of the 37 amperes full-load stator current. In shunt with this resistor, there was a 3-phase reactor with a closed iron circuit, designed to draw about one quarter of the total rotor current under locked rotor, full voltage conditions, and in series with each phase of this reactor was a resistor of 0.03 per-unit ohm. With this arrangement, the motor had about 10% slip at rated voltage and torque. The actual drop in full-load speed was about 14%, as shown in Fig. 9, because the motor voltage at the full-load torque point was considerably less than the rated value of 380 volts, because of the drop in the series reactors.

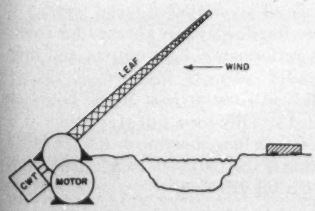

Fig. 7. Single-leaf bascule bridge.

As Fig. 9 indicates, the motor speed with this arrangement could be set at any desired value from +1,800 to −1,800 rpm, and the motor then maintained at this speed, with a reasonable amount of droop, over the full range from maximum motoring torque to maximum braking torque.

The primary reactors in this scheme are merely a means of varying the motor voltage to obtain the desired torque

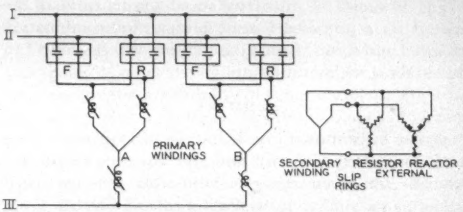

Fig. 8. Dual-winding connection for reactor speed control.

at all times. When the desired torque is less than that given by the motor operating on full voltage at the same speed, the motor voltage must be reduced correspondingly. If the ratio of the actual torque to the full-voltage torque at the same speed is α^2, the operating voltage and current of the motor will each be α times the values taken from the full voltage torque and current curves, and the total kva drawn by the motor will be α times the kva taken at the same speed with full voltage impressed.

Thus, the power factor of the motor at reduced torques will be α times the normal motor power factor at the same speed. However, under maximum torque conditions at each speed, the primary reactors will be fully saturated, and the voltage drop in them then will be relatively small. Accordingly, the output obtainable from the motor with the reactor control scheme is only slightly less than the normal full-voltage value. The effect of the reactors is to reduce the power factor and increase the motor heating over the light load range, with little sacrifice in performance at high loads.

By designing the reactors to saturate more or less completely, or by providing oversized amplistats to supply control currents well in excess of normal, or by designing

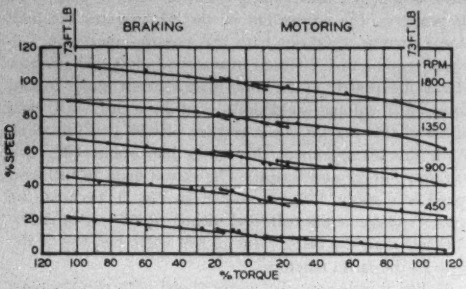

Fig. 9. Speed–torque curves of dual-winding motor with reactor speed control.

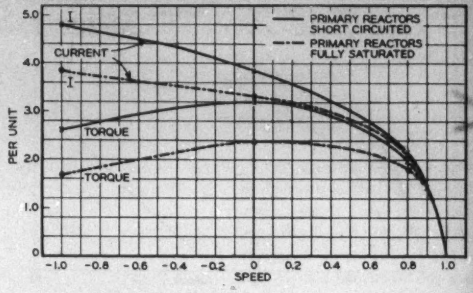

Fig. 10. Calculated speed–torque curves of motors for proposed bascule bridge with reactor speed control.

the motor for a rated voltage somewhat less than the system voltage, thus making an allowance for the voltage drop in the reactor, or by a combination of these methods, the maximum output and average power factor values can be adjusted to suit the requirements in each case most effectively.

Fig. 10 shows the calculated speed–torque curve of the motors for a proposed bascule bridge. Any combination of speed and torque inside the limiting values shown can be obtained without difficulty.

SUMMARY

IT HAS BEEN SHOWN that by means of amplistats, feedback control circuits, and saturable reactors, a standard wound-rotor motor can give adjustable constant speed performance similar to a Ward Leonard Electric Company d-c drive, over the complete range from +100 to −100% of normal torque. The kva rating of the primary reactors required to give this performance is roughly 80% of the kva rating of the motor. However, differences in normal current densities, temperature rises, and methods of rating for motors and for reactors make an exact statement of the requirements difficult.

A noteworthy feature of the dual-winding reactor speed control scheme is that it provides automatic braking (by "plugging" the motor) to bring the speed down promptly to a desired lower value, or to rest, without overshoot; it also provides high accelerating torque to bring the motor promptly to a desired higher speed.

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Life Testing of Electroluminescent Lamps

Life testing of Panelescent (registered trade mark) lamps produced by Sylvania Electric Products, Inc., as shown here, is an integral part of the quality control program for the redesigned electroluminescent light sources. The lamps, now made of porcelainized metal instead of the heavier and more fragile glass, are checked for color, uniformity of light, performance, light output, and durability.

These lamps, which will last at least 30,000 hours or more, can be operated steadily for a full year's time at a nominal annual cost. An announcement was recently made of the production of the 200,000th Panelescent lamp by the company's Lighting Division.

Outdoor vs Indoor Steam Electric Stations

L. K. DEL'HOMME
FELLOW AIEE

THE CONTROVERSY over the relative merits of outdoor and indoor generating stations will probably persist for a long time, but for the Houston (Tex.) Lighting & Power Company the question has been resolved definitely in favor of outdoor plants. This decision is based on its own experience in pioneering the development of the outdoor design in the Texas Gulf Coast area.

The mild climate of the Houston area, coupled with a promised advantage in capital cost, initially focused attention on the outdoor station design. The first step in this direction was a 25-mw semi-outdoor extension to an indoor plant in 1939, where only the boiler and its induced draft fan were installed outdoors.

Advances made in the development of outdoor station design and of equipment suitable for outdoor application permitted installation in 1949 of the company's first full outdoor station. This was the Greens Bayou "A" Station, consisting of two 60/66 mw preferred standard units. This installation has served as the prototype for all subsequent stations, and although improvements and refinements have been made from time to time, the basic outdoor design has remained unchanged.

This design is based on construction of plants in multiples of two units with two operating levels. The weatherproofed turbine-generators are located on an open deck in front of the boilers and are served by one gantry crane. A common control room is located between the boilers at the turbine-generator operating floor level. This is the only building in the plant proper. Principal auxiliaries are located at grade, which is the second operating level. There is no basement. Auxiliary transformers and 2,300- and 480-volt switchgear are completely outdoors, while boiler feed pumps, condensate pumps, and other auxiliaries are more or less protected by the control room and operating deck above them.

Full outdoor capacity on the system in 1952 was 282 mw, or 45.9% (per cent) of total; in 1956 it is 838 mw, or 63.1% of total, consisting of nine generating units, ranging in size from 66 to 156 mw installed in four stations; and in 1959 it is expected to be 1,306 mw, or 72.8% of total. Experience thus far with outdoor-type generating station construction and operation has been entirely satisfactory in the Houston area and nothing has been encountered which would suggest that the present policy should be reversed or even modified.

Capital cost is a major factor to be considered between the outdoor and the conventional indoor plant. Since no conventional indoor plant has been constructed on the Houston system since 1932, comparable actual cost data are not available; however, it is estimated that at least $10.00 per name plate kw is saved by the full outdoor type of construction, with a proportionately smaller saving for the semi-outdoor type. This saving results from elimination of costly boiler and turbine enclosures and basements, from the compact arrangement of equipment made possible by the outdoor design, and from the more convenient working conditions on outdoor construction.

While there is an over-all cost advantage in the construction of an outdoor plant, it is true that equipment suitable for outdoor application is more expensive than indoor equipment. This additional cost varies with the size of the installation and the degree of weatherproofing required. For the Sam Bertron 156 mw (name plate) unit which was completed this year, it is estimated that weatherproofing of the turbine-generator, motors and auxiliary switchgear cost about $0.58, $0.23 and $0.15 per kw, respectively, a total of $0.96 per kw.

The chief advantages of outdoor stations from the standpoint of construction are reduction in construction time and greater accessibility of the equipment. The construction period is shortened by elimination of the boiler and turbine-generator buildings. Location of auxiliary switchgear and most of the motors in the open permits a traveling crane to move the equipment to the site and set it directly on the foundation.

Manpower requirements are less for the outdoor station. Four men per shift are required to operate a 2-unit gas-fired outdoor plant. For a 4-unit plant the operating personnel is increased to seven. In addition, maintenance, supervisory, and clerical forces and guards are required, as in all types of plants.

Because of the reduced manpower requirements, operating costs of outdoor stations tend to be lower than those of other stations. A recent survey[1] showed that for nine stations of approximately the same rating, a full outdoor type, gas-fired plant located in the Gulf Coast area had the lowest total operating cost, the second lowest number of employees and was second highest in mw of peak per employee. Total operating cost for this station in 1954 was 1.269 mills per net kwh including fuel and 0.263 mills excluding fuel. The remaining eight stations appear to be indoor or semi-outdoor plants equipped to burn coal. At least one burned fuel oil.

Operation of outdoor plants on the Houston has been satisfactory. In the early installations a number of motor failures occurred as the result of moisture, but since modern "weather-protected" motors became available, no trouble attributable to outdoor installation has been experienced.

Digest of paper 56-769, "Outdoor vs Indoor Steam Electric Stations in the Houston Area," recommended by the AIEE Committee on Power Generation and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Summer and Pacific General Meeting, San Francisco, Calif., June 25-29, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, February 1957.

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First Principles of Semiconductors

C. A. ESCOFFERY

The reader is introduced to some of the main points of semiconductor phenomena. Concepts of wave properties of electrons, discrete energy levels, free electrons in metals, and band theory of solids, show how semiconductors differ from metals and insulators. This is followed by a discussion of doping to create impurity conduction (n and p type), and of the relationship of conductivity to carrier concentration, life-time, and mobility.

ON THE BASIS of electrical conductivity, solids can be broadly classified into metals, semiconductors, and insulators. Because of the rapidly growing prominence of semiconductors in electronic technology, the average engineer has become interested in acquiring a greater understanding of semiconductors but his efforts are hampered by the esoteric language of the physicist. It is hoped that this article may be of aid by presenting a brief review of some of the main points of semiconductor phenomena.

However, in order to obtain a reasonably clear picture of semiconductors, it is necessary to invade the field of solid-state physics and become partially acquainted with the band theory of solids. To do so, a review of some of the present-day concepts of the behavior of electrons, first in individual atoms, then in metals, and finally in semiconductors, must be undertaken.

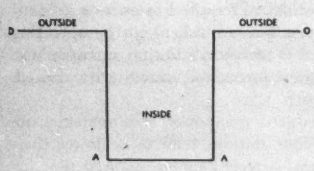

Fig. 1. Potential box of a metal.

WAVE PROPERTIES OF ELECTRONS

IN DEALING WITH MATTER of very small dimensions such as atoms, electrons, and protons, modern physics makes it possible and even desirable to consider them as wave motion rather than as particles. Electrons can, in fact, be diffracted (scattered in definitely determined directions) by passing them through thin crystals.

The "wave length" of a moving electron is related to its mass and velocity by the De Broglie equation

$$\lambda = \frac{h}{m v} \qquad (1)$$

where h is a very important constant of proportionality known as Planck's constant. Thus, for instance, the wave length of an electron with one volt of kinetic energy (traveling at a speed of 1½ million miles per hour) would be about 12×10^{-8} cm. This is of the same order of magnitude as the spacing between atoms in a crystal, and explains why electrons can be diffracted.

Since electrons can be considered as (mathematical) waves, many of the equations involved in their treatment resemble those used in describing familiar examples of wave motion such as vibrating strings and oscillating electrical circuits.

Now, it is necessary to define discrete energies. A system that can have any frequency of oscillation, such as a spinning wheel, can have any value of energy. But if only certain frequencies are permitted, as in the case of a violin string fastened at both ends, then only certain definite, discrete energies are permitted. In the case of the vibrating string, the permitted frequencies are, of course, the familiar overtones or harmonics.

The same considerations apply to electrons in an atom. Only certain energy overtones or energy levels are permitted because, like the violin string, the electrons are tied down. The mathematician would say they are subject to boundary conditions.

ELECTRONS IN METALS

FROM CHEMISTRY it is learned that only the outermost electrons in an atom determine its chemical valence. In discussing the conductivity of solids, only these electrons are considered "free," the rest being bound rather strongly to the nucleus. Only the "free" valence electrons are capable of conducting an electric current and, therefore, only valence electrons shall be considered from now on.

In order to study the behavior of these electrons in a metal, matters must first be simplified by considering these electrons as being confined to a potential field like that in Fig. 1. Here O, the potential energy of the electrons outside of the metal, is arbitrarily chosen as zero for convenience; inside of the metal, the potential energy A is constant. Because electrons do not ordinarily escape from a metal, they must have a lower (more negative) energy inside than outside. In this simplified model, the electrons move in the field, which is regarded as constant and equal to zero outside of the metal, and constant and equal to A within.

As in the violin string and in the individual atom, so

A special article recommended for publication by the AIEE Committee on Solid-State Devices.

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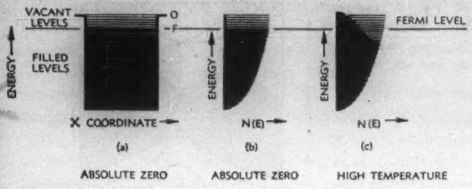


Fig. 2. (A) Schematic of electron energy levels in a metal with the potential field of Fig. 1. In (B) and (C), the number of electronic states for each energy interval is shown for two different temperatures.

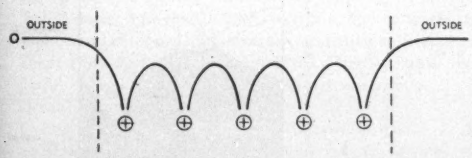


Fig. 3. Periodic potential field in a crystalline solid. The circled crosses represent atoms.

too in Fig. 1 the "boundary restrictions" give rise to a discrete energy spectrum. But now there is a difference: due to the very large number of atoms, we find a very large number of energy levels, all very close together, giving rise to what is known as a quasicontinuous spectrum, as indicated schematically in Fig. 2(A).

In Fig. 2, the occupied levels are indicated by heavy horizontal lines, whereas the empty levels are indicated by light lines.

An examination of Fig. 2(A) reveals that there is a sharp transition between the filled and the vacant levels and, furthermore, that even at the absolute zero of temperature the electrons are distributed over a very wide range of energy. The reason for the latter follows from what is known as the Pauli exclusion principle, which states that only one electron can be in a given energy state at one time. Two electrons can occupy a given energy level but they must have opposite spins.

Once an energy level is filled by a pair of electrons (with opposite spins), additional electrons must go to higher levels. The value of energy *OF* is called the work function of the metal, and it expresses the energy needed to liberate an electron from the metal.

If the number of allowed energy levels in each energy interval in Fig 2(A) is plotted, the type of energy distribution shown in Figs. 2(B) and 2(C) is obtained. At absolute zero, the maximum electronic energy level is called the Fermi level; at higher temperatures, some electrons can have higher energies than the Fermi level, as shown in Fig. 2(C).

In order for an electron to conduct a current, it must be accelerated; that is, its energy must be increased. In the absence of an applied field, there is no net drift of electrons and, hence, no observable current even though some electrons are moving about with velocities as high as 250,000 miles per hour.

By means of considerations such as outlined in this section, the conductivity of a metal can be expressed by an equation relating it directly to its electronic mean free path. Since the mean free path decreases as the temperature is raised (due to scattering of the electron waves by increasing lattice imperfections), the conductivity of a metal decreases with increase in temperature, as is actually observed in practice.

BAND THEORY OF SOLIDS

THUS FAR, in considering the movement of the valence electrons in a metal it was assumed that they move in a uniform electrostatic field within the crystal (Fig. 1). In

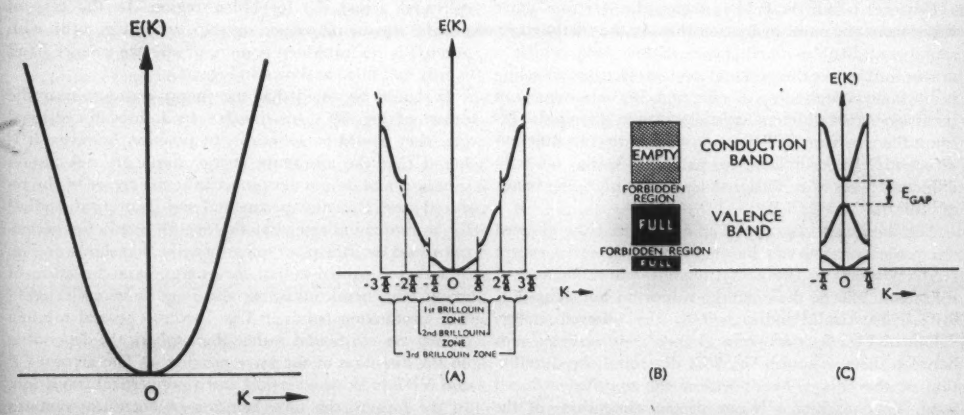
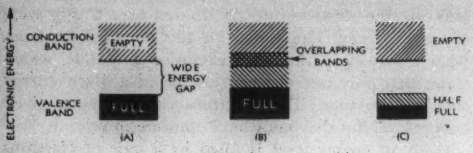
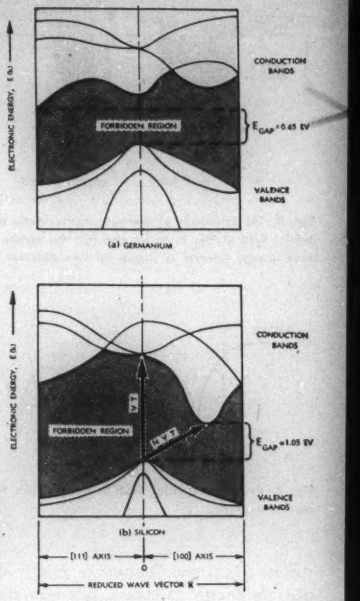


Fig. 4. (*Left*) Energy of a perfectly free electron moving in a uniformly constant force field as a function of wave number *k*. Fig. 5. (*Right*) (A) Energy of an electron as a function of wave number for the periodically varying field of Fig. 3. The gaps in the energy curve give rise to forbidden energy regions which are indicated schematically in (B). By translation of the energy curves into the first zone (C) is obtained from (A).



◀ **Fig. 6. Energy level diagrams for (A), an insulator; (B) and (C), metals.**



▶ **Fig. 7. Schematic diagrams of the energy band structures at room temperature for germanium and for silicon along the 111 and 100 axes.**

effect, this is only an approximation. It is known that the atoms in a crystal are arranged in a regular array, and because of the concentration of a positive charge in the nucleus, the electric field would be expected to vary and to be strongest in the immediate vicinity of the atoms, as indicated schematically in Fig. 3.

Furthermore, inasmuch as the electrons have wave properties, the electron waves would be expected to interact with the crystal's varying electric field and to be diffracted by the lattice atoms just like X rays are diffracted. Therefore, electrons with certain critical velocities and directions would be reflected, with the result that the corresponding energy states would not exist. It will be seen shortly that these nonexistent energy states give rise to what is known as forbidden energy regions as shown in Fig. 5(B).

In the case of a free electron moving in a uniform field, the energy is given by the familiar relationship

$$E = \frac{mv^2}{2} \tag{2}$$

whence, by substitution of the value of v from equation 1

$$E = \frac{h^2}{2m\lambda^2} \tag{3}$$

If λ is replaced by a reciprocal quantity k, called the wave number, and then the relationship between E and k is plotted, the energy values fall on a parabola, as shown in Fig. 4. This corresponds to the case of a perfectly free electron.

However, when the field in which the electrons move varies from one point to another (Fig. 3), the results correspond somewhat to those shown in Fig. 5(A), which is drawn for the one-dimensional case of electrons traveling in the same crystallographic direction. Wave numbers can be assigned for different crystallographic directions. Because the crystal periodicity may be different in different directions, the forbidden gaps in Fig. 5(A) may occur at different values of k. This may lead to overlapping bands as indicated in Fig. 6(B).

The significant aspect of Fig. 5(A) is that the allowed electronic energy levels lie on a parabolic curve except for certain regions (forbidden regions) where, because of diffraction effects, these energy values do not exist. Fig. 5(B) schematically indicates how the allowed energy values of Fig. 5(A) fall into "bands" with energy gaps between them, whereas Fig. 5(C) illustrates the distribution of the energy bands within the so-called reduced zone. The quantity a is one of the dimensions of the unit cell crystal.

It must be emphasized that within the allowed bands the energy levels are so close together as to be almost continuous. Nevertheless, they are still separate (discrete) and must conform to the Pauli exclusion principle which determines how many electrons can occupy each energy state.

Band energy diagrams are very useful for they allow explanation of the difference between metals and insulators. Thus, as shown in Fig. 6(A), the energy gap between the highest (full) band and the next higher (empty) band in insulators is so large that the electrons cannot be accelerated across the forbidden region. In the case of metals, the bands either overlap as in Fig. 6(B) with essentially no forbidden regions, or else the valence band is only half filled as shown in Fig. 6(C).[1]

It should be noted that the energy contours near the center of Fig. 5(C) are circular. In a three-dimensional plot they would be spherical. In practice, however, it is found that the minimum energy states are not always spherical and do not always occur at the center of the reduced zone. Recent experimental and theoretical studies[2] for instance, indicate that the energy bands for germanium and for silicon are somewhat like that shown in Fig. 7, and it is probable that the energy band structure of many other semiconductors also is quite complicated.[4,5] The conduction bands in Fig. 7 exhibit several minima (which are ellipsoidal rather than spherical), depending on the direction of the wave number k. The arrows VT and NVT indicate a vertical and a nonvertical transition. In the former, the wave number (momentum) remains constant; the energy gap, however, is the smallest energy distance between bands, as indicated by the nonvertical transition.

There is another way of viewing the energy band picture—when the individual atoms (with their permissible discrete energy levels) are brought together to form a solid, each allowed energy level broadens out into a series of levels, so numerous and close together that they are practically continuous within each band. This broadening is due to interaction of the atoms with each other as they come closer together. A similar situation occurs in other mechanical systems (e.g., in coupled oscillators), where the amount of interaction is related to the amount of coupling. Thus, the resonant peaks of inductively coupled tuned circuits are found to broaden with increased coupling, giving rise to the well-known double hump above a certain value of the coupling coefficient.[6] Fig. 8 shows how the discrete electronic energy levels (far right-hand side) broaden, overlap, and then split apart to form a low-lying band separated from higher bands by a large energy gap. Dashed line shows separation at the actual atomic spacing.[7]

For this discussion, the most important factor is the existence and magnitude of the energy gap between the valence and conduction bands. If the gap is large and the valence band is filled, conduction will not be observed. In metals, the bands usually overlap and the electrons in the valence band can easily be raised to higher, empty levels by the application of an electric field.

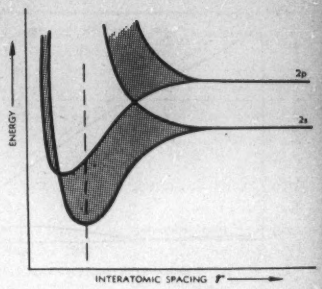


Fig. 8. Broadening of electron energy levels into bands as the atoms of carbon are brought closer together to form the crystal lattice of diamond.[7]

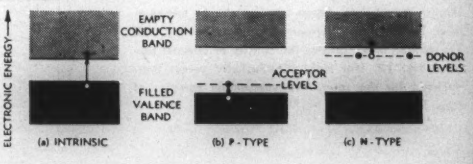


Fig. 9. Electronic energy diagrams for semiconductors. Circles represent positive holes and dots represent electrons.

IMPURITY LEVELS

IT IS NOW EASIER TO UNDERSTAND how the electrical properties of semiconductors are explained in terms of their energy bands. If the energy gap is small enough, as seen in Fig. 6(A), so that electrons can be excited thermally from the lower filled valence band to the upper empty conduction band, an intrinsic semiconductor exists.

Now, when an electron moves into the higher band (energetically speaking), not only can this electron carry a current, but so can the vacancy left behind in the valence band as shown in Fig. 9(A). This vacancy, which acts like a positive electronic charge, is called a defect electron, a positive hole or, more simply, a hole. The concept of conduction by holes is basic to the modern theories of semiconductors.

In most semiconductors, however, the value of the energy gap is too large for intrinsic conduction to take place at room temperature, and the observed conductivities are explained on the basis of what is known as impurity conduction. According to this view, impure (or extrinsic) semiconductors owe their conductivity to the presence of additional discrete energy levels located within the forbidden energy region. When the impurity levels lie close to the top of the (full) valence band as shown in Fig. 9(B), they are able to accept electrons from the valence band and, therefore, are called acceptor levels. In this case, the semiconductor is said to be p-type, because most of the current is carried by positive holes. The holes left behind in the valence band are free to move. The electrons that moved up into the acceptor levels do not, as a rule, conduct because these levels are localized and not distributed continuously throughout the crystal.

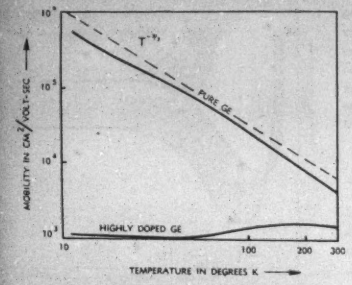
On the other hand, when the impurity levels lie close to the bottom of the (empty) conduction band shown in Fig. 9(C), they will donate electrons to the conduction band wherein they will be free to move. The impurity levels are here called donor levels and the semiconductor is termed n-type because most of the current is carried by negative charges.

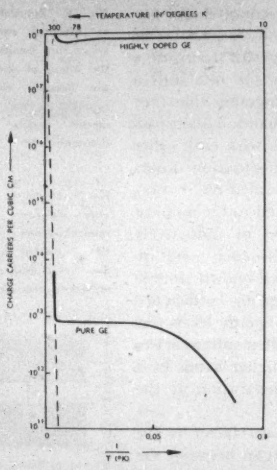
We thus distinguish two types of semiconductors, p and n type, respectively. To illustrate how n and p type semiconductors can be prepared by suitable doping, consider germanium and silicon, two widely used elements from the fourth group of the periodic table of the elements.

These elements have a chemical valency of four due to their four valence electrons, and their atoms tend to join together by means of "covalent" bonds. In every covalent bond, two electrons are found equally shared by the two atoms. Inasmuch as the covalent bond is very stable, the electrons are not free to conduct and, therefore, under normal conditions the electrical conductivity will be low. (As the temperature is increased, however, the conductivity increases because electrons and holes are produced in equal numbers whenever a bond breaks.)

If additional electrons are now introduced into the crystal lattice by adding elements from Group V (such as arsenic or phosphorus), the additional energy levels will be located somewhat like those shown in Fig. 9(C). Greatly enhanced conductivity will be observed because the energy difference between the donor levels and the conduction band is relatively small, of the order of 0.01 electron-volts for germanium and of 0.05 for silicon.[8] These values are small when compared with the room temperature energy gap values of approximately 0.065 for germanium and 1.08 for silicon given in Table I.

The additional electrons come from the donor atoms. Thus, when an arsenic atom is substituted for one of germanium, there is an electron left over which can contribute to the conductivity to an extent dependent on how firmly attached it is to the arsenic atom.





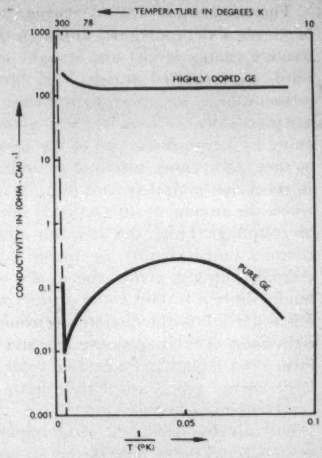


Fig. 10. (Above) Variation of mobility with temperature for two samples of germanium. Fig. 11. (*Right*) Density of charge carriers versus temperatures for the same germanium samples of Fig. 10. The dashed line indicates the density of intrinsic carriers. Fig. 12. (*Far right*) Conductivity versus temperature for the same two germanium samples of Figs. 10 and 11.

Similar consideration applies to the preparation of p-type germanium or silicon by doping with Group III elements, such as boron or aluminum. These atoms, which have only three valence electrons, will create holes (lack of electrons) in the valence band, introducing acceptor levels within the forbidden region, as indicated in Fig. 9(B).

When the concentration of impurities in the semiconductor becomes very large, we find the semiconductor becoming metallic in character. It is then said to be degenerate. Under such conditions, the number of charge carriers is practically independent of temperature as indicated in Fig. 11.

RECOMBINATION, LIFETIME AND MINORITY CARRIERS

As discussed in connection with Fig. 9, carriers are created by either intrinsic or extrinsic excitation. But at the same time that carriers are being generated (through absorption of radiation or by injection through a suitable contact, as in a transistor), they also are being destroyed through recombination. Under conditions of equilibrium, the rates of generation and of recombination are equal, and the number of charge carriers will be given in equation 5.

It has been found that these generation and recombination rates are related to the so-called mean lifetime of the minority carriers. For our purpose, the latter can be considered as the average length of time that the minority carrier exists between generation and recombination. Lifetimes in semiconductors depend on the state of perfection and of the purity of the crystal. Values as high as 0.001 to 0.01 seconds have been obtained in high purity germanium; the values in silicon and in other semiconductors are lower.

Although direct recombination of holes and electrons has been observed in germanium and in silicon, the most important recombinations processes in most semiconductors appear to be those occurring at the surface and in the bulk by means of recombination centers, or energy levels within the forbidden region. These centers may consist of lattice imperfections, vacant lattice sites, interstitial atoms, and impurities. In many cases, a carrier that has dropped into such an intermediate energy level will be thermally re-excited and released before it recombines with a carrier of opposite sign. In such cases, the recombination center is often called a trap.

CONDUCTIVITY, MOBILITY, AND CONCENTRATION

The electrical conductivity of a semiconductor is determined both by the number of mobile charge carriers and the facility with which these carriers move under an applied field. The latter property is called the mobility and is defined as the drift velocity per unit field.

The actual expression for conductivity, σ, is given by

$$\sigma = \sigma_n + \sigma_p = ne\mu_n + pe\mu_p \qquad (4)$$

where n and p are the electron and hole concentrations, e is the electronic charge, and μ_n and μ_p are the electron and hole mobilities, respectively.

From equation 4 one can see that in order for the conductivity to increase with temperature, the product of concentration and mobility must increase. In practice, it is found that the conductivity at first tends to increase with rise in temperature, and then at higher temperatures it tends to decrease (illustrated by the sample labelled "pure" in Fig. 12).

The variation in mobility with temperature for two samples of n-type germanium is shown in Fig. 10, while the temperature variation of the carrier concentration for the same two samples is shown in Fig. 11. The sample marked "pure" contained less than 10^{13} charge carriers per cm^3 at room temperature, or about one conduction electron for every 5½ billion germanium atoms! The other sample was highly doped with arsenic[9,10] to about 8×10^{18} carriers per cm.^{3}

Fig. 12 illustrates how the conductivity varies with temperature, for the same two samples of Figs. 10 and 11. Because the number of carriers and the mobility are relatively constant for the impure sample, the conductivity is also a constant as a function of temperature.

With respect to the concentration of electrons and holes at any given temperature, equation 5 states that the product of these two quantities is a constant, regardless of the purity of the semiconductor:

$$pn = n_i^2 = \text{constant } T^3 \left[\exp\left(\frac{-E_g}{kT}\right) \right] \qquad (5)$$

where p and n are the hole and electron concentrations, n_i the intrinsic concentration, T the absolute temperature, k Boltzmann's constant, and E_g the thermal energy gap of the forbidden region. The cubed term indicates why the number of carriers increases so rapidly with temperature.

The conductivity of a semiconductor is given in equation 4. By means of separate measurements of the conductivity and of the mobilities one obtains values for the concentrations n and p. In most semiconductors, the electron mobility is greater than the hole mobility. Some typical values for a number of semiconductors are given in Table I. The very high electron mobility of indium antimonide, in particular, leads to pronounced magnetic effects and a number of technological applications have already been proposed for this material.[11,12]

Table I. Energy Gaps and Mobilities in Semiconductors at Room Temperature

	E_g electron volts	μ_n, cm^2 per volt-second	μ_p, cm^2 per volt-second
Si	1.08	1200	500
Ge	0.65	3900	1900
Grey Sn	0.09	~ 2000*	~ 1000*
Boron	~ 1.1	—	—
Hexagonal Se	~ 1.7	—	< 10
Te	0.32	830	540
Black P	0.33	220	350
Grey As	1.20	—	—
Iodine	~ 1.3	—	—
CdS	2.4	210	—
CdSe	1.7	~ 100	—
CdTe	1.5	600	50
Cd_3As_2	0.6	—	—
PbS	0.30	600	~ 250
PbSe	0.22	1175	868
PbTe	0.27	1200	475
ZnS	3.60	—	—
ZnSe	2.58	—	—
ZnTe	2.2	—	—
ZnSb	0.55	—	—
Mg_2Si	0.77†	—	—
Mg_2Ge	0.74†	530	106
Mg_2Sn	0.33†	320	260
Mg_3Sb_2	0.8	—	—
InP	1.25	3400	650
InAs	0.35	30000	~ 200
InSb	0.18	77000	~ 1250
GaP	2.3	—	—
GaAs	1.3	4000	> 250
GaSb	0.7	4000	850
AlSb	1.6	1200	200
$CuInS_2$	1.2	—	—
$AgInSe_2$	1.18	—	—
$CuInSe_2$	0.92	300	26
$AgInTe_2$	0.96	—	—
$CuInTe_2$	0.95	—	—
$CuFeS_2$	0.53	—	—

* At 0 degrees centigrade
† At 0 degrees Kelvin

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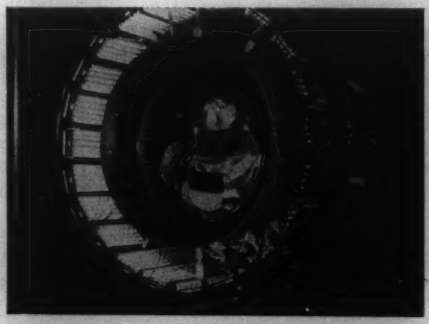
Probing the Thermal Barrier

Engineers of the Structures Test Laboratory of North American Aviation, Inc., study the effect of simultaneously heating and cooling a metal ring simulating a portion of an aircraft's fuselage. The outside of the ring is heated to about 450 F by the battery of infra-red lamps that encircle it, while the inside is cooled to 90 F by cold air blown through perforated aluminum tubes. At the same time, hydraulic devices pull at the metal to simulate stresses that might be encountered in flight. Through the maze of tubes and wires runs power for the lamps, air for cooling, and electronic impulses that automatically report strain and temperature data to a battery of recording devices. It takes a man about a week to evaluate data recorded in a few minutes of one of these tests.



Determination of Stray Load Loss in D-C Machines

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ASSOCIATE MEMBER AIEE

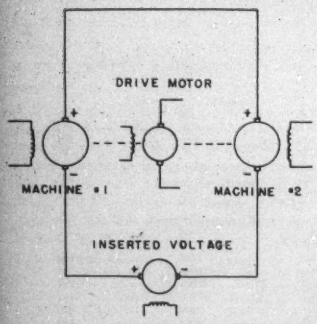

Fig. 1. Circuit diagram.

A SPECIALLY DEVISED METHOD using the Blondel load-back principle of loss measurement has been employed to measure the stray load loss in d-c machines. An inherently accurate value of the loss is obtained by measuring it as two separate components by a method which is direct and easy to perform.

If two similar d-c machines are directly coupled to a drive motor by a common shaft and their internally generated electromotive forces are made equal and opposite around a closed loop, then an inserted voltage will cause a current to flow around the loop, impeded only by the total apparent resistance of the complete armature circuit of the two machines. This inserted current will produce generator action in one machine and motor action in the other, as indicated in Fig. 1. The two electromechanical conversions cancel each other and the total machine losses are supplied by the mechanical power from the drive motor plus the electric power inserted in the armature loop. The difference between the total power supplied to the two machines with and without the inserted voltage includes only the armature loop resistance loss and stray load loss, inasmuch as all other losses are specified as constant with constant speed and excitation.

Results were obtained giving the stray load loss measured as the two separate components: (a) the core-loss component, and (b) the armature-circuit component. This is in agreement with the ASA (American Standards Association) code which defines the stray load loss as: "Losses due to eddy currents in the copper and additional core loss in the iron produced by distortion of the flux by load current except that due to *IR* drop; and short-circuit loss of commutation."

This method for determining stray load loss has the advantage of simplicity. Changes in various parts of the armature circuit of a d-c machine, such as armature copper temperature, and brush and brush-contact drop, which normally cause difficulties and errors in accurate measurement, are reduced to a minimum in this test. In employing this method, it is not necessary to know the values of any of these separate quantities. All that is required for a particular value of armature current is that the two different measurements of armature-loop input be made under the same load and temperature conditions. The latter is readily accomplished by making these measurements with the smallest practical lapse of time. The stray load loss component is eliminated in the second measurement by operation at low speed and zero field flux while maintaining the same temperature and brush-contact drop.

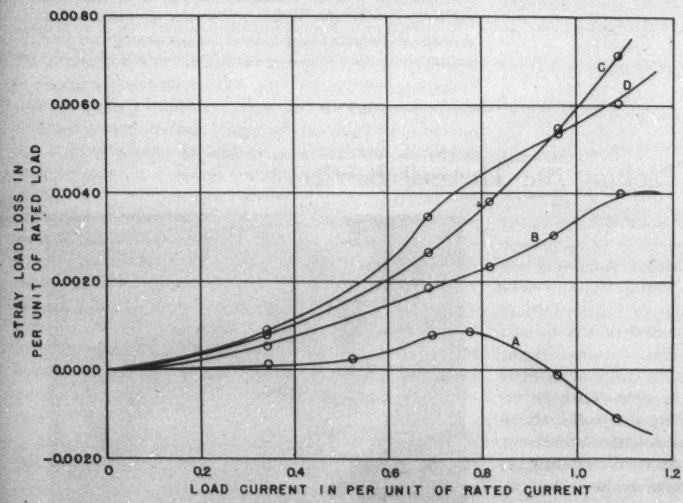

Fig. 2. Stray load loss curves.

Digest of paper 56-39, recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Committee on Technical Operations for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30-February 3, 1956. Scheduled for publication in AIEE *Power Apparatus and Systems*, 1957.

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Design and Calculation of Induction Heating Coils

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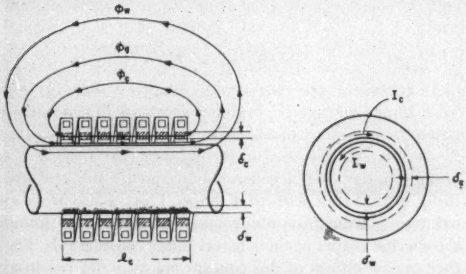

Fig. 1. A typical induction heating load.

WHEN ALTERNATING CURRENT flows in the coil turns of a typical induction heating load, such as shown in Fig. 1, three components of magnetic flux are established, i.e. (1) in the workpiece, (2) in the air gap, and (3) in the copper of the coil turns. This is characteristic of any induction heating load regardless of shape, size, or frequency, and a general equation can be written for total flux linking the coil turns in terms of the magnetizing force H_o established at the surface of the work. The rate of change of total flux determines the voltage E_c which must be applied to oppose the counter electromotive force and establish the field intensity H_o. The current which flows in the coil consists of two components: the one proportional to and in phase with H_o, and the other proportional to and in phase with the product of total flux Φ_o and the reluctance of the external flux path. The first is the current which would flow if the external reluctance were negligible (long coil), and its ampere-turns are reflected exactly in the induced current in the workpiece. The second simply supplies the external magnetic drop and its ampere-turns are not reflected in the workpiece. If the coil voltage is divided by coil current, an expression for coil impedance is obtained which is interpreted in the equivalent circuit of

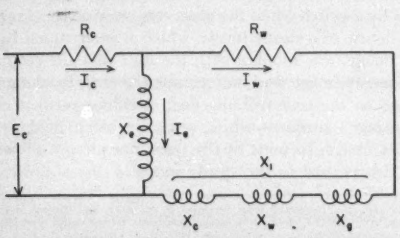

Fig. 2. Equivalent circuit, short coil.

Fig. 2. The work current I_w flows through reflected work resistance R_w, air-gap flux reactance X_g, work flux reactance X_w, and copper flux reactance X_c. The current I_e which supplies the external magnetic drop flows through the shunt reactance X_e. The total coil current I_o is the sum of these two and it flows through the ohmic resistance of the coil R_c. The circuit may be solved by conventional analytical methods. Expressions for the circuit constants are easily derived.

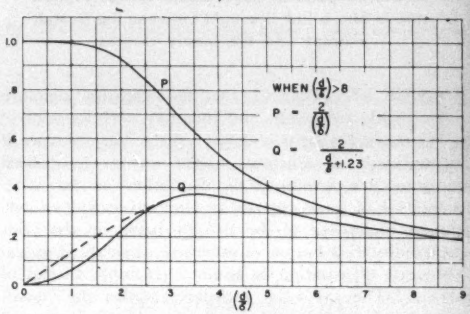

Fig. 3. P and Q curves, solid cylinder.

The method is sufficiently general to allow use of the same procedure in calculating a variety of jobs. This is accomplished by introducing into the equations two dimensionless parameters, P and Q, characteristic of load geometry. Individual curves of P and Q are plotted for geometries which are likely to be encountered. For example the P and Q curves for a solid cylinder are shown in Fig. 3. For convenience, the abscissa of this curve is the ratio of load diameter to the effective depth of current penetration calculated from the physical constants of the load material. Magnetic permeability must be considered in calculating δ, R_w, and X_w, when the load is magnetic.

An attempt has been made to establish a complete, albeit approximate, method of calculation suited as well to the casual user as to the expert. The method has been checked experimentally over the range of frequencies commonly used in induction heating (60 cycles to 450 kc). Its accuracy is adequate for negotiation and design work, especially since in the latter it is usually customary to provide a coil with taps or to feed it from a tapped transformer.

Digest of paper 57-4, recommended by the AIEE Committee on Electric Heating and approved by the AIEE Technical Operations Department for presentation at the AIEE Winter General Meeting, New York, N. Y., January 21-25, 1957. Scheduled for publication in AIEE *Applications and Industry*, 1957.

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Some Studies in the Speed of Visual Perception

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Normalized detail content of transmitted TV scenes is less than 5 per cent compared with artificial subjects, indicating observer preference influences the transmitted subject. Verification tests were devised involving reading, character, and object recognition in precisely measured periods. To evaluate the perception rate in bits, a link is sought between the Gestalt concept and the binary choices.

THE STATEMENT that the television signal is highly redundant and therefore very wasteful of channel capacity is almost a cliché. Various types of redundancies of different subject matters have been measured, which indicate the truthfulness of that statement.[1-3] A method proposed by Gouriet[1] provides a continuous indication of the entropy based on the joint probability distribution of successive elements, if an exponential distribution is assumed (example at end of article). The particular instrument called the "detail meter" differentiates the signal, provides an integrated value of the absolute value of the derivative, obtained by full-wave rectification in a normalized form, where a maximum change at every picture element is called 100 per cent detail. This instrument gives the maximum reading for a television signal corresponding to vertical bars (or a checkerboard) with the maximum resolution of the system (325 lines) but gives a reading of only 33 per cent for a noise spectrum since the criteria of the exponential distribution are not satisfied. More significantly, however, when the instrument is connected to a video program line the reading is normally less than 3 per cent and seldom is a reading in the order of 6 per cent obtained. In the laboratory, special subjects may be selected with substantially higher readings; however, these scenes would not be considered pictures with entertainment value.

The detail meter thus indicated a viewer preference for low detail or information content. Although some work in this field analyzed so-called typical pictures, the project of finding either typical or preferable pictures was not considered. A clue was supplied by the psychologists, particularly by Professor Y. LeGrand of Sorbonne, who performed some perception tests with images, which were to be sketched by an artist after a short exposure. These tests indicated that even after several seconds of exposure only the contours are perceived. This is, of course, simply in line with the Gestalt recognition of a subject.

GESTALT CONCEPT

THE GESTALT CONCEPT was developed about 1912 by Max Wertheimer, who founded a school of psychology based on it.[4] The word Gestalt means form, shape, configuration, etc. It is used in the concept that a person, by being familiar with a general shape, will associate something in that class with that shape. Thus, a leaf from an oak tree or from an apple tree is recognized even though the specific shapes of their leaves differ considerably. Further considerations of this concept are quite far reaching, but this short definition may be considered adequate.

At this point, the problem is to establish a relationship between the Gestalt concept and some unit familiar to the communication engineer; to provide a display which exposes the subject for a variable but precisely measured time, and to find a suitable way for obtaining a measure of the observation.

One may consider each letter of the alphabet or each number a Gestalt; then knowing that random letters correspond to 4.7 bits per symbol, a relationship between a class of subject and the Gestalt may be established. The perception of random letters, however, cannot be measured too easily and they form a rather limited class of Gestalts. Nevertheless some reading speed tests and short exposure tests were performed and some of the results will be reported when evaluated.

THE TEST SETUP

IN ORDER TO CONTROL the exposure period precisely, an electronic switching system was developed to switch video signals. The switching gear operates from the video synchronizing pulses, switching from one signal to another at the beginning of a field and switching back to the first signal again after 2, 4, 8, 16, 32, 64, or 128 fields (or correspondingly, after approximately 1/30, 1/15, 2/15, 1/4, 1/2, 1, and 2 seconds). The exposure time to the second signal can be set beforehand and the changeovers actuated by a switch when the observers are ready.

The use of a steady image, which is interrupted by the test image, was adopted with the idea that the reappearing steady image does not permit the storage of the test image on the retina. This effect could be verified easily by using a uniform white, gray, or black field as the steady image. In most of the tests, the picture shown in Fig. 1 was used as the steady image.

Revised text of a conference paper presented at the AIEE Fall General Meeting at Chicago, Ill., Oct. 1-5, 1956, at a session sponsored by the AIEE Committee on Communication Theory.

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Fig. 1. Steady image used in perception test.

Fig. 2. Preliminary to test, this slide was flashed at various exposure fields.

The display device was a television station monitor with a 12-inch kinescope. The observers were asked to view the screen as they would view a television receiver. Generally, a distance from 5 to 7 times the picture height was used. As a preliminary experiment, the slide shown in Fig. 2 was flashed on for about 20 observers and they were asked to recite what they had seen as soon as possible after exposure to the picture. A stenographer took down their remarks. For two fields of exposure (1/30 second) the observers noticed a change but could not tell what they saw. For an exposure of four fields they recognized either the horse or the house, but not both. In 16 fields (approximately 1/4 second) they observed two connected objects such as: "a white horse pulling something," or "house and trees," "house with windows" and even reported inventions such as "a pony with a rider," "a house and a street, and I think there was a car in the street."

In connection with these experiments, it was already notable that (1) the center of the picture was perceived first; (2) the majority of the observers, after recognizing one object, tried to name more by conjecture; (3) the number of objects recognized by the different observers for the same periods were remarkably uniform; and (4) a given total exposure in these experiments seemed to yield the same amount of recognition whether it was taken in one exposure or in two exposures, each lasting half of the total period.

THE RELATIONSHIP BETWEEN BITS AND GESTALTS

In the next experiment, an attempt was made to evaluate the perception in bits and to eliminate any relationship between the recognizable objects. The slide shown in Fig. 3 was prepared and the evaluation of each object in bits was based on the following reasoning. C. K. Ogden[5] lists 200 picturable nouns among his 1,000 basic words. Four of the five objects were among these; the pyramid, however, was not. Since it would have been a formidable job to count all the pictureable nouns in a complete dictionary, a sampling technique was used and a factor of 4.7 was found for the letter B and a factor of 5.1 for the letter S between the basic English list and the Webster dictionary[6]. This provides an estimate of 1,000 picturable nouns or for each Gestalt approximately 10 bits of information ($\log_2 1024$). On the basis of this estimate it was then possible to test the perception speed in a bits-per-second scale.

PERCEPTION SPEED TESTS

The procedure of the test with slide 3 was the same as that used with the previous slide. The first test with 8 fields (approximately 1/8 second) was inadequate for all observers to recognize any of the objects. A typical answer was, "approximately eight small figures in three columns that appeared to be line drawings of mythical animals." With an exposure of 16 fields (approximately 1/4 seconds) all observers recognized the fish. The test with an exposure period of 32 fields (approximately 1/2 second) was performed with 50 observers including engineers, stenographers, janitors, etc. Only 1 out of the 50 could name three objects. With one exposure who named the pipe and the scissors in that order, the rest named the fish and one more object. In all the tests with any exposure periods (about 120 tests altogether) if an object were recognized at all, the center figure was the first named figure.

The recognition of two independent objects corresponds to 20 bits and since the exposure was 1/2 second, it corresponds to 40 bits per second perception speed. It may be interesting to compare this figure with the capacity of a television signal channel. The number of different messages that can be constructed with 200,000 picture elements per frame with 100 distinguishable brightness levels is $10^{400,000}$. On the basis of the relationship of $2^x = 10^{400,000}$ and $X = 400{,}000/\log_{10}2$, this corresponds to approximately 1.3 million bits per frame or 40 million bits per second.

It was felt that once the technique described was developed, the perception speed should be verified with Gestalts of smaller classes, and therefore shorter periods. One experiment with a slide which had objects with names all starting with the letter *B*, failed to produce a greater object recognition higher than two per 32 fields after the observers were instructed about the restriction. A discussion of this observation with some of the viewers made it evident that this type of restriction imposes a difficult mental process, which apparently causes a slowing down in the perception speed.

Another experiment, in which the observer was shown the chart of 16 symbols shown in Fig. 4 beforehand and then asked to recognize one of these symbols, yielded excellent consistency between tests and the results obtained with the general class of picturable nouns. By flashing the single symbol (corresponding to four bits) for 4 fields (1/15 of a second) or 60 bits per second, only 1 out of 20 observers guessed the correct symbol, which

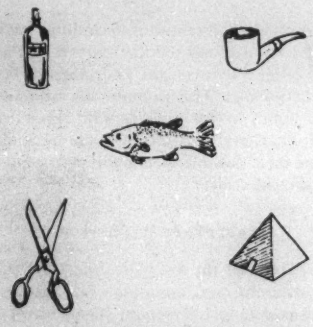

Fig. 3. Slide employed to evaluate the perception in bits and to eliminate any relationship between recognizable objects.

might even be accounted for on the basis of chance. When the exposure period was doubled (8 fields, 2/15 second) and, therefore, the perception rate demand was reduced to 30 bits per second, only one of another group of 20 observers failed to recognize the right symbol in this experiment.

The importance of the steady picture before and after the exposure of the unknown picture was demonstrated easily by the use of the symbol test: with the steady picture the symbol could not be recognized in 8 fields; but if the exposure to the symbol were followed by a blank screen, one field (1/60 of a second) was enough to pick the right symbol. Based on these tests it is believed that where an image is flashed on and off by optical means the retinal retention is tested rather than the perception speed.

One further test involved the instruction to the observer that the symbol to be shown is a choice of two of the symbols from Fig. 4, thus each recognition corresponds to 1 bit of information received correctly. The speed for this test was set at 1/30 of a second and we expected to perform a large number of tests in order to get an average; however, the 30 bits per second provided per-

Fig. 4. Chart shown before observer is asked to recognize one of the symbols.

fect recognition every time and accordingly 10 tests were considered to be conclusive.

EXAMPLE

The probability that a signal level i will be followed by level j and that such succession will appear provides a rate of information

$$H = -\sum i\ j\ p_i\ p_i\ (j) \log p_i\ (j) \tag{1}$$

The quantity measured by the detail meter

$$D = K \int e \frac{d\,B}{d\,x}\, d\,x \tag{2}$$

where B is the brightness of an element and x is the horizontal distance. Substituting signal levels i and j for brightness the integral may be evaluated by the Monte Carlo method[7] as

$$D = K \sum |i\text{-}j|\, p_i\, p_i\ (j) \tag{3}$$

If we assume that

$$p_i\ (j) = e^{-K^2 |j-i|} \tag{4}$$

equations 1 and 3 become equal.

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INSTITUTE ACTIVITIES

Peacetime Uses of Atomic Energy To Be Topic of 1957 Nuclear Congress

PEACETIME USES of atomic energy will be the topic of the 1957 Nuclear Congress, scheduled for March 11-15, 1957, at Convention Hall, Philadelphia, Pa., under the co-ordination of Engineers Joint Council (EJC). The session will bring together leaders in science, engineering, industry, Government, education, agriculture, and other fields.

Included in the Congress are four major events one of which is the Second Nuclear Engineering and Science Congress, co-ordinated by EJC on behalf of 20 engineering and scientific societies. This will include 130 technical papers during a 4-day program.

The National Industrial Conference Board will hold its Fifth Conference on Atomic Energy in Industry, featuring 12 round-table discussions, a dinner on Thursday, March 14, and a luncheon meeting on March 15.

The International Atomic Exposition, sponsored by the American Institute of Chemical Engineers in co-operation with four other engineering societies, will display industry's latest items in the atomic field.

The Fifth Hot Laboratories and Equipment Conference, sponsored by the Hot Laboratories Committee of the Oak Ridge National Laboratory, Oak Ridge, Tenn., will take place March 14-15. It will deal with the operation and development of equipment for laboratories for atomic energy.

Dr. W. G. Whitman of Massachusetts Institute of Technology, president of the American Institute of Chemical Engineers and secretary-general of the United Nations "Atoms for Peace" Conference in Geneva, Switzerland, 1955, is general chairman for the 1957 Congress. According to Dr. Whitman, "The 1957 Nuclear Congress will continue the remarkable co-operation among engineers and scientists from almost every portion of the globe and from every branch of science and engineering for the benefit of mankind, that was first evidenced at Geneva and later at the first EJC Congress in Cleveland, Ohio, in 1955. Progress in the civilian uses of atomic energy is being immeasurably expedited through this co-operative action."

Commenting generally on the congress, Dr. T. H. Chilton, president of EJC, said that "the true value of the congress does not lie in its sheer size. Its significance lies in the fact that there will be an opportunity to gather in one place at one time, representatives of all of the many arts and sciences that are concerned with the rapidly growing field of atomic energy."

"This will be an unparalled demonstration of true unity of purpose and action, both within the engineering profession and within the larger field of science and technology. This program promises to be an outstanding one, both from the point of view of lasting contributions to peacetime uses of atomic energy and as a sterling example of inter-professional co-operation."

Program chairman for the 1957 Nuclear Congress is Bruce Prentice (M '47) of General Electric, member of the Executive Committee of the American Society of Mechanical Engineer's (ASME) Nuclear Engineering Division and member of American Nuclear Society (ANS). T. A. Marshall, Jr., assistant secretary of ASME is congress manager and L. R. Gaty (F '50), vice-president of the Philadelphia Electric Company, is chairman of the Philadelphia Arrangements Committee.

J. S. Sinclair, president of the National Industrial Conference Board, notes that "never before have business men been able to attend three large integrated conferences and a trade fair on atomic energy within the same week. The EJC is to be congratulated for its efforts to eliminate unnecessary duplication of meetings in this field."

Attendance at the Nuclear Congress is expected to exceed the 3,000 at the Cleveland, Ohio, Congress in December of 1955. The International Atomic Exposition, which drew 18,000 persons in Cleveland, expects many more interested observers at its displays in Convention Hall in March. The Exposition reports that it will be bigger and more diversified than before, with many firms exhibiting for the first time and with space reservations being made at a record rate. J. V. Friel, exposition director, observes that reservations for the exhibitions are 20 per cent ahead of the 1955 Exposition, with 3 out of 10 companies being new to the field.

Presented at the Nuclear Engineering and Science Congress will be 130 technical papers dealing with various phases of nuclear operations from mining to the disposal of radioactive waste. Emphasis will be on new developments of potential value to civilian industry, especially in the fields of metallurgy, chemical processing, mechanical, and power application.

Topics which will be covered by the Fifth Atomic Energy In Industry Conference are fusion, recent developments in radiation chemistry and radio-isotopes-applications, foreign and domestic markets for atomic energy products, nuclear propulsion, waste disposal, health and safety problems, the economics of new reactor types, the latest developments in atomic energy legislation, site selection problems for nuclear facilities, and problems in local and state atomic energy regulations.

The 1957 Congress, all ready supported by 20 major United States engineering, scientific, and management groups, also expects representatives from other nations to participate in various aspects of the meetings and to exhibit at the Exposition.

In addition to the four major organizations, the following partial list of organizations will be represented at the 1957 Congress: AIEE; American Society of Civil Engineers; American Institute of Mining, Metallurgical and Petroleum Engineers;

Courtesy Jules Schick

DISCUSSING the 1957 Nuclear Congress to be held March 11-15, at Convention Hall, Philadelphia, Pa., are *(left to right)* L. R. Gaty (F '50), chairman of the Philadelphia Arrangements Committee and vice-president of the Philadelphia Electric Co.; E. J. Van Antwerpen, secretary, American Institute of Chemical Engineers; Dr. T. H. Chilton, president, Engineers Joint Council; and T. A. Marshall, Jr., secretary, American Society of Mechanical Engineers, and manager, 1957 Nuclear Congress.

American Society of Mechanical Engineers; American Waterworks Association; American Society for Engineering Education; Society of Naval Architects and Marine Engineers; American Institute of Chemical Engineers; American Institute of Industrial Engineers; American Chemical Society; American Institute of Physics; The Institute of Radio Engineers; American Geological Institute; American Society for Metals; Institute of Aeronautical Sciences; Society of Automotive Engineers; American Society for Testing Materials; and Federation of Sewage and Industrial Wastes Association.

February Conference Being Held on Transistor and Solid-State Circuits

THE 1957 Transistor and Solid-State Circuits Conference to be held February 14-15, at the University of Pennsylvania, is sponsored jointly by the Science and Electronics Technical Division of the AIEE, the Philadelphia Section of the Institute of Radio Engineers (IRE), the IRE Professional Group on Circuit Theory, and the University of Pennsylvania. Patterned after the previous conferences held at the same location for the past several years, this conference will include information on both linear and nonlinear transistor circuits. Also, one session will be devoted to other solid-state circuits, including ferroelectrics and magnetic cores. Two tutorial sessions are aimed at surveying recent advances in the subject and will provide the practicing engineer in solid-state circuitry a broader picture of the state of the art.

Although no conference transactions will be published, a technical addendum to the program booklet will be available at the time of registration, containing reproductions of all slides, including mathematical expressions.

The Bellevue-Stratford Hotel, Broad and Chestnut Streets, Philadelphia, Pa., has reserved a block of rooms for those attending the conference.

Registration and hotel reservation forms are being mailed to members of the sponsoring groups. Others may obtain them from F. W. Anderson, General Electric Company, Missile and Ordnance Systems Department, 3198 Chestnut St., Philadelphia 4, Pa. Fees for the conference are as follows: advance registrations made before February 7, $3.00; Thursday luncheon, $2.50; cocktail buffet, $6.00; and Friday luncheon, $2.50; registration at conference, $4.00; Thursday luncheon, $3.00; cocktail buffet, $6.50; and Friday luncheon, $3.00.

Because of limited facilities, and to assist the Local Arrangements Committee, advance registration is urged.

The tentative technical program for the conference follows.

Thursday, February 14

8:00 a.m. Registration—Irvine Auditorium

9:30 a.m. Switching Circuits—Irvine Auditorium

Chairman: J. L. Walsh, IBM Engineering Laboratory

A Decade Ring Counter Using Avalanche-Operated Junction Transistors. *J. E. Lindsay*, Radio Corporation of America

Transistor Circuits for Magnetic Drum Recording. *Gordon Kuster*, Ferranti Electric Limited

Large Scale Testing of Switching Speeds of Junction Transistors. *Irwin Dorros*, Bell Telephone Laboratories

Effects of Low Temperatures on Transistor Characteristics. *A. B. Credle*, International Business Machines Corporation

9:30 a.m. Tutorial A—University Museum Auditorium

Chairman: T. H. Bonn, Sperry Rand Univac

A Survey of Solid-State Devices for Control and Information Handling Systems. *J. A. Rajchman*, RCA Laboratories

Bias Considerations in Transistor Circuit Design. *S. K. Ghandi*, General Electric Company

12:00 Noon Lunch—University Museum Egyptian Gallery

2:00 p.m. Formal Opening of Conference—Irvine Auditorium

Formal opening of conference and presentation to University of Pennsylvania by A. L. Samuel, chairman of conference; G. L. Haller, past chairman of conference; and J. G. Brainerd, University of Pennsylvania

2:30 p.m. Computer Switching—Irvine Auditorium

Chairman: R. E. McMahon, MIT Lincoln Laboratory

Millimicrosecond Transistor Current Switching Circuits. *H. S. Yourke*, IBM Laboratory

DCTL Complementing Flip-Flop Circuits. *E. G. Clark*, Burroughs Research

A New Bistable Transistor Element Suitable for Digital Computers. *N. F. Moody*, Defense Research Board

An Analysis of the Complementary Pair Trigger Circuit. *C. D. Florida*, Defence Research Board

A Complementary Symmetry Monostable Multivibrator. *C. F. Chong, A. I. Aronson*, Radio Corporation of America

The Design of Dual-Range Transistor Circuits for Minimum Standby-Current Systems. *H. E. Tompkins*, University of Pennsylvania

2:30 p.m. Linear Amplifiers—University Museum Auditorium

Chairman: A. P. Stern, General Electric Company

Transistor Low Noise Preamplifier with High Input Impedance. *A. E. Bachmann*, General Electric Company

Wide Band Feedback Amplifiers. *F. D. Waldhauer*, Bell Telephone Laboratories

A Transistorized High Voltage Push-Pull Sweep Generator Using High Impedance Techniques. *P. J. Anzalone*, Radio Corporation of America

Series Tuned Methods in Transistor Radio Circuitry. *W. F. Chow, D. A. Paynter*, General Electric Company

A New Approach to Transistor Receiver Design. *A. Proudfit, K. M. St. John, C. R. Wilhelmsen, R. J. Farber*, Haseltine Research Corporation

6:00 p.m. Cocktail Buffet—Bellevue-Stratford Hotel

8:00 p.m. Informal Group Discussions—Bellevue-Stratford Hotel Conference Rooms

Friday, February 15

8:30 a.m. Registration

9:00 a.m. Power Circuits—Irvine Auditorium

Chairman: H. T. Moores, Minneapolis-Honeywell

Some Solutions to Problems of Operating Germanium Transistor Servo Amplifiers at High Ambient Temperatures. *P. M. Thompson, J. Mitchell*, Defense Research Board

Phase Controlled Transistor Power Supply Regulation. *D. E. Deuitch*, Radio Corporation of America

Transistor D-C Amplifier Utilizing "Firing-Angle" Control. *H. R. Lowry*, General Electric Company

An Improved Square-Wave Oscillator Circuit. *J. L. Jensen*, Minneapolis-Honeywell

Three-Phase Static Inverter. *T. M. Corry, R. P. Puskovich*, Westinghouse Electric Corporation

A New Tramag Oscillator. *A. J. Meyerhoff, R. M. Tillman*, Burroughs Research Center

9:00 a.m. Tutorial B—University Museum Auditorium

Chairman: F. H. Tendick, Bell Telephone Laboratories

Characteristics and Application of New High Frequency Transistors. *R. L. Pritchard*, General Electric Research Laboratories

Design of High Frequency Amplifiers. *G. T. Lake*, Defense Research Board

12:00 Noon Lunch—University Museum Egyptian Gallery

2:00 p.m. Special Device Circuits—Irvine Auditorium

Chairman: Chaang Huang, Sylvania

Temperature Compensation of Transfluxors. *H. W. Abbott, J. J. Suran*, General Electric Company

Counting Circuits Using Ferroelectric Devices. *R. M. Wolfe*, Bell Telephone Laboratories

Switching Characteristics of Magnetic Cores as Circuit Elements. *R. D. Torrey, A. Krell, C. Meyer*, Sperry-Rand Univac

Transient and Frequency Response Characteristics of Field Effect Unijunction Transistors. *J. J. Suran, B. K. Eriksen*, General Electric Company

AIEE Sponsors Second Farm Electrification Conference

The second Conference on Farm Electrification, sponsored by the AIEE, was held at the Hotel Peabody, Memphis, Tenn., October 29-31, 1956.

The program was of great interest to all who deal in supply, distribution, or promotion of electric power for farm use. The papers presented were by men who are recognized as experts in their respective fields. The subjects covered included: descriptions of a new general purpose farm motor and a new submersible pump motor; selection and application of irrigation equipment; electrical grounding in rural structures; a need for larger motors on the farm; philosophy and economics of using more electricity; educational techniques for promoting greater use of electricity on the farm; and how the use of electricity has made automation of the poultry industry practical.

In addition to these subjects, the conference was opened with a paper on the little-known subject "The Role that Light and Radiation Plays in Agriculture," and ended with a look into the future with "Electric Service Unlimited for the Farms of Tomorrow."

Woodard's Photographers

AMONG THOSE at the second AIEE Conference on Farm Electrification were: (*back row, left to right*) R. D. Barrett, secretary, Memphis Section; A. R. Beasley, chairman, Hospitality Committee; L. H. Heyman, chairman, Registration Committee; H. F. Hemker, general chairman; J. H. Oliver, program chairman; H. W. Kelley; (*front row, left to right*) R. S. Gardner; J. W. Widmer; G. C. Davis, chairman, Memphis Section; and W. E. Goodman, chairman, Finance Committee.

An interesting feature of the meeting was an inspection trip to several electrically operated farms, including one of the largest and most progressive farms of the South.

The total attendance at this conference was over 160, with representatives from 26 states. There were 61 members, and 91 nonmembers present that were definitely so listed.

The interest and enthusiasm of those who attended was so marked that the Committee is now planning another conference for next year. There is every indication that the attendance will be greater at a future conference.

Philadelphia Section Reports on Recent Activities

The December meeting of the Philadelphia Section of the AIEE featured a talk by Peter Freeman of the Glenn L. Martin Co. on "The Earth Satellite Project." Mr. Freeman spoke primarily about the launching of the rocket "The Vanguard" with particular emphasis on the control of this three-stage finless rocket. He indicated that approximately 12 of the satellite carrying rockets will be launched during the 1957 International Geophysical Year (IGY). Of these, possibly seven will be for test purposes only and will return to the ground as dust. The remainder, it is hoped, will remain in orbit.

J. A. Bowman, general manager—special projects, American Telephone and Telegraph Co., spoke at the January meeting. His talk, entitled "The Voice Beneath the Sea," dealt with the problems of engineering and laying the transatlantic telephone cable. Mr. Bowman presently is in charge of the engineering for the Alaska-Hawaii telephone cables. H. U. Davis, American Telephone and Telegraph Co., chairman of the Section Papers and Meetings Committee was in charge of the program.

The "Creative Engineering Symposium," jointly sponsored by the Philadelphia Sections of the AIEE and Institute of Radio Engineers (IRE), was a pronounced success with an advance registration of 300. The six-session symposium was planned by the Section Education Committee, W. O. Mascaro, Atlantic Refining Co., chairman. The final arrangements were completed by the Subcommittee on Symposiums and the Symposium Operating Committee under the chairmanship of R. S. Berkowitz, University of Pennsylvania; and R. L. Rocamora, Radio Corporation of America; respectively.

Speaking at the February meeting, which is also Students Night, will be S. Charp of the Franklin Instiute. His subject will be "Guided Missiles."

The March meeting occurs at the time of the 1957 Nuclear Congress which is to be held in Philadelphia, Pa., this year. The meeting will tie in with the Congress and will deal with future applications of atomic energy.

AIEE Bonus for Married Engineers?

Marriage between electrical engineers may reap extra dividends from AIEE. At least it has for one couple who were brought together by an AIEE Section meeting.

George and Louisa Cook, of Phoenix, Ariz., had lived within three blocks from each other. Only they never knew it.

While George was off to war with the Navy, Louisa was attending the University of Arizona Engineering College and working during the summer recesses at the Bureau of Reclamation, Yuma, Ariz. After she graduated, Louisa obtained a position with the Salt River Power District in Phoenix

Future AIEE Meetings

AIEE-IRE-U of P Conference on Transistor and Solid State Circuits*
University of Pennsylvania,
Philadelphia, Pa.
February 14-15, 1957

AIEE-IRE-ACM Western Joint Computer Conference*
Hotel Statler, Los Angeles, Calif.
February 26-28, 1957

Textile Conference*
Georgia Institute of Technology,
Atlanta, Ga.
March 7-8, 1957

EJC Nuclear Engineering and Science Congress*
Convention Hall, Philadelphia, Pa.
March 11-15, 1957

AIEE-ASME Engineering Management Conference*
Pittsburgh, Pa.
March 27-28, 1957

Paper and Pulp Conference*
Georgia Institute of Technology,
Atlanta, Ga.
March 28-29, 1957

Southern District Meeting*
Hotel Heidelberg, Jackson, Miss.
April 3-5, 1957

Rubber and Plastics Conference
Akron, Ohio
April 8-9, 1957
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Feb. 1)

AIEE-AWS Electric Welding Conference
Municipal Auditorium,
Philadelphia, Pa.
April 8-12, 1957
(Final date for †TP—closed, ‡CP Syn.—closed, CPMs—Feb. 1)

Great Lakes District Meeting
Hotel Fort Des Moines,
Des Moines, Iowa
April 15-17, 1957
(Final date for †TP—closed, §DP Syn.—closed, DPMs—Feb. 8)

AIEE-IRE Solid State Dielectric and Magnetic Devices Conference
Catholic University, Washington, D.C.
April 22-23, 1957
(Final date for †TP—closed, ‡CP Syn.—Feb. 6, CPMs—Feb. 15)

Electric Heating Conference
Commodore Perry Hotel,
Toledo, Ohio
April 23-24, 1957
(Final date for †TP—closed, ‡CP Syn.—Feb. 7, CPMs—Feb. 15)

*Final date for submitting papers—closed
†TP—Transactions Paper
‡CP Syn.—Conference Synopsis
CPMs—Conference Manuscript
(The CP Syn. date is 10 days before the CPMs date)
§DP Syn.—District Synopsis
DPMs—District Manuscipt
(The DP Syn. date is 10 days before the DPMs date)

TWO AIEE members, Louisa Cook (*left*) and her husband, George Cook (*right*) are shown with a potential new member, their son, Robert Louis Cook (*center*).

Gene Boyce, Photographer

under the supervision of F. L. "Monte" Roe, a long time member of AIEE who introduced her to AIEE activities.

Following his Navy discharge at the end of hostilities, George also attended the Engineering College at the University of Arizona. Upon graduation he worked for Convair in California and then returned to Phoenix as an employee for Motorola Research in September 1953.

It was then, at an Institute Section meeting in nearby Prescott, Ariz., that George and Louisa met, and later were married. These two who, in order to meet, had to follow a devious route paved by their desire to be electrical engineers and AIEE members, wrote to the Institute hoping to take advantage of their unusual case by making one dues payment on a joint dues membership. This was not possible, but officers of the Institute thought something should be done in honor of this rather unique couple.

Subsequently, a bargain was struck. The Cooks were told that if AIEE could count on a potential new member, an equitable adjustment would be made. Within a year, the transaction was closed with the birth of Robert Louis Cook, who will begin his professional activities about 1977.

All electrical engineers, both actual and potential, who read this, should be reminded that the above does not constitute a standing AIEE offer. However, to those in similar circumstances, it might be said: You can't lose anything by trying, especially if the Institute has played cupid for you, too.

Vice-President's Certificate Presented

Courtesy C. B. Brown

J. R. WALKER (F '48) of Billings, Mont., was presented with a certificate in recognition of his services to the Institute as vice-president from the North West District, 1954-56, at a joint meeting of the Montana Section and the Billings Subsection, held in Billings on November 15, 1956. The presentation was made by H. L. Baker, who has succeeded to the chairmanship of Montana Section after the former chairman, William Wheeler, moved from Montana. Among those at the presentation were (*left to right*) R. L. Barta, vice-chairman, Billings Subsection; W. F. Thompson, Thompson, Slaybaugh and Thompson, Denver, Colo.; C. R. Beitman, chairman of the Subsection; Mr. Walker; Mr. Baker; E. W. Head, Control Corporation, Minneapolis, Minn., the featured speaker of the evening; and C. W. Lee, secretary-treasurer of the Subsection.

Alfred Noble Prize Won by Dr. Mortada

A technical petroleum paper by Mohamed Mortada, senior engineer for the Magnolia Petroleum Co., Dallas, Tex., has achieved the distinction of being chosen for the Alfred Noble Prize, the major award of five top engineering organizations to a young engineer for an outstanding paper.

Dr. Mortada, a member of the American Institute of Mining, Metallurgical, and Petroleum Engineers (AIME) also has been announced as the winner of the Institute's Rossiter W. Raymond Award for his paper, "A Practical Method for Treating Oilfield Interference in Water-Drive Reservoirs," published in the AIME *Journal of Petroleum Technology*. Both awards will be conferred at the annual AIME meeting in New Orleans, La., February 24-28, 1957.

Besides AIME, the Alfred Noble Prize sponsors are the AIEE, American Society of Civil Engineers, of which the late Mr. Noble was a president; The American Society of Mechanical Engineers, and the Western Society of Engineers. Mr. Noble also served as president of the latter.

In considering Dr. Mortada's paper, the award committee, headed by Dr. H. S. Rogers, president of Polytechnic Institute of Brooklyn, presented the following report on the importance of the paper:

"This is original work. It has been known, of course, that unexpected pressure values were frequently found in oil well drilling. Pressure in one area of a field is known to be affected by drilling in another area. Pressure effects are transferred from one area to another through the aquifer (water bearing sands) underlying the oil sands. This work of Mortada provides charts, heretofore unavailable, which enable producers to anticipate, for extended periods of production, pressure changes at immediate and remote areas over a particular aquifer. This knowledge enables better control of production costs, oil recovery and valuation."

Dr. Mortada is a junior member of AIME. He received the degree of B.S. from the University of Cairo and the degrees of M.S. and Ph.D. from the University of California.

The award is given annually for a paper of exceptional merit accepted for publication by one of the societies ". . . provided the author has not passed his 31st birthday at the time the paper is submitted to the society in practically its final form."

Tau Beta Pi Badge Awarded to Woman Engineer

Mrs. F. F. Buckland (M '48) of the General Electric Company, Schenectady, N. Y., one of the nation's foremost women engineers, has been awarded the Women's Badge of the Tau Beta Pi Association, national engineering honor society.

The presentation was made by the Massachusetts Institute of Technology (MIT), where Mrs. Buckland graduated in 1920.

The citation was given Mrs. Buckland ". . . in recognition of high scholastic stand-

ing as an undergraduate and in view of outstanding attainments in the field of engineering."

Mrs. Buckland is a heat transfer applications engineer with General Electric's General Engineering Laboratory, Schenectady, N. Y. She has attained national recognition for her work on heat transfer problems involving rotating machinery, electrical household appliances, switchgear, locomotives, and giant turbines.

Her husband, son, and son-in-law all are engineers. Her husband, B. O. Buckland, is the consulting engineer of General Electric's gas turbine department in Schenectady and a member of Tau Beta Pi. Her son, Lt. L. F. Buckland, was graduated from MIT in 1952 and is currently with the U. S. Air Force Research and Development Center, Griffiss Air Force Base, Rome, N. Y. Her daughter, Mrs. W. L. Kitchens of Costa Mesa, Calif., is married to a Beckman Instrument Company engineer.

A native of Cambridge, Mass., Mrs. Buckland was graduated from high school in Billings, Mont. She was one of two women in her class at MIT, where she received a bachelor's degree in electrochemical engineering.

She joined General Electric as a turbine engineer in 1921, and in 1925 earned a master's degree in electrical engineering from Union College, Schenectady. She was the first woman to receive such a degree from Union.

Officers Elected for NEMA Product Sections

At the recent National Electrical Manufacturers Association (NEMA) Convention, the following new officers of NEMA Product Sections, several of whom are AIEE members, were elected.

Semiconductor, Metallic Rectifier Section—Julian Loebenstein (M '48), sales manager, Radio Receptor Co., Inc., chairman

Specialty Transformer Section—R. H. Sommers, vice-president, Transformer Division, Hevi-Duty Electric Co., chairman of Section; W. C. Anderson, chief project engineer, Jefferson Electric Co., chairman of the Section's Technical Committee

Capacitor Section—M. E. Scoville (F '49), manager, engineering capacitor department, General Electric Company, chairman of Section; B. H. Schultz (AM '49), chief engineer, capacitors and regulators, Line Material Co., Division of McGraw Electric Co., chairman of the Power Capacitor Technical Committee; M. S. Hook, chief engineer, Electrical Utilities Co., chairman of the Specialty Capacitor Technical Committee

Transformer Section—R. N. McCollom (AM '47), sales manager, Transformer Division, Westinghouse Electric Corporation, chairman

Transmission and Distribution Voltage Regulator Section—L. Wetherill (F '48), manager of engineering, power transformer department, General Electric Company, chairman

Laminated Products Section—E. R. Perry, president, National Vulcanized Fibre Co., chairman of the Technical Committee; W. L. Rodich, general manager, laminated and insulating products department, General Electric Company, chairman of the Section; C. R. Mahaney, vice-president and general manager, Panelyte Division, St. Regis Paper Co., chairman of the Decorative Laminate Group

Manufactured Electrical Mica Section—C. G. Plimpton, Jr. (AM '21), vice-president, New England Mica Co., Inc., chairman

Vulcanized Fibre Section—H. C. Steadman, vice-president and general manager, Taylor Fibre Co., chairman

Varnished Fabric and Paper Section—R. J. Gavin, vice-president and general manager, Irvington Varnish and Insulator Division of Minnesota Mining and Manufacturing Co., chairman

Conduit Fittings Section—M. D. Bergan (M '49), engineering technical director, The Thomas & Betts Co., chairman of the Section's Technical Committee; T. W. Briegel, president, B. M. Fitting Corp., chairman of the Section

Switchgear Section—T. G. A. Sillers (M '43), chief engineer, switchgear department, Power Equipment Division, Allis-Chalmers Manufacturing Company, chairman of Technical Advisory Committee; L. W. Long (M '44), assistant general manager, Power Equipment Division, Allis-Chalmers Manufacturing Company, Section chairman.

Conference Papers Open for Discussion

Conference papers listed below have been accepted for AIEE *Transactions* and are now open for written discussion until March 1. Duplicate double-spaced typewritten copies of each discussion should be sent to E. C. Day, Assistant Secretary for Technical Papers, American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y., on or before March 1.

56–260 Measurement of the Complex Dielectric Constant of Very High Dielectric Constant Materials at Microwave Frequencies. Isadore Bady

56–757 Magnetically Keyed, Phase-Sensitive Demodulators. *R. B. Mark, W. S. Johnson, P. R. Johannessen*

Preprints may be purchased at 40¢ each to members, 80¢ each to nonmembers, if accompanied by remittance or coupons. Please order by number and send remittance to: AIEE Order Department, 33 West 39th St., New York 18, N. Y.

North Eastern District Meeting

IN CHARGE of the AIEE North Eastern District Meeting to be held in Pittsfield, Mass., May 1-3, are: *(left to right)* F. H. Judkins, in charge of finance; J. O. Sweeny, general chairman; and H. S. Hubbard, advisor. All technical sessions and social activities will take place at the Wendell-Sherwood Hotel, where accommodations will be available for guests. The program includes trips through the General Electric Company's power transformer and distribution transformer departments as well as social activities for members and their wives. The details will be announced shortly.

Three New Fellows Honored

Courtesy Ross Photos

SMILING over an important milestone in their lives are three Fellows of the AIEE recently raised to the Institute's highest grade. They were honored during ceremonies at a New York Section Family Night Meeting December 12. AIEE awards Fellowships to members who have served with distinction in the electrical engineering profession. The new Fellows are: (*left to right*) W. K. Sonneman, Westinghouse Electric Corporation, Newark, N. J.; S. L. Scheffer, Burns & Roe, Inc., New York, N. Y.; and T. D. Reimers, Consolidated Edison Company, Inc., New York, N. Y.

Joint District Meeting Planned

Courtesy Delco Products Division, GMC

THE DAYTON, OHIO, SECTION will be host to the East Central District 11, the Middle Eastern District 2, and the National Air Transportation Committee May 7-9, 1957. Donald Warren (*left*) has been appointed general chairman of the meeting by Robert O'Brien (*right*), chairman, Dayton Section. They are shown inspecting part of the test apparatus for polyphase integral motors at the Delco Products Division, General Motors Corporation. This and other testing equipment will be seen during the Delco plant visit which will be part of the May meeting. Other trips are planned to Chrysler Air Temp, National Cash Register, A. O. Smith Corporation, Wright-Patterson Air Force Base, and others. The theme of the meeting will be Rotating Electrical Equipment and Air Transportation. Manufacturers exhibits on electric components for motors and aircraft will be on display. Member and student papers will be presented on subjects appropriate to the theme as well as several on engineering management.

Molded Case Breaker Section—A. R. Johnson, division manager, Cutler-Hammer, Inc., chairman

Panelboard and Distribution Board Section R. G. Oakley, sales manager, panelboard-manufacturing and repair department, Westinghouse Electric Corporation, chairman

Industrial and Commercial Lighting Equipment Section—J. H. Fall, III, vice-president in charge of sales, Benjamin Electrical Manufacturing Co., chairman

Floodlighting Section—J. A. McDougall, general sales manager, Revere Electric Manufacturing Co., chairman

Wiring Device Section—A. W. Gilmore, general manager, wiring device department, General Electric Company, chairman

Industrial Control Section—F. E. Beede, sales manager, Ward Leonard Electric Co., chairman of the Section; E. R. Jung, vice-president in charge of marketing, The Clark Controller Co., chairman of the Section's Advisory Committee

Power Rectifier Conference To Be Held in Chicago, Ill.

The Industrial Power Rectifier Committee and the Metallic Rectifier Committee of AIEE are sponsoring a joint conference with the Chicago Section on Rectifier Equipments as they are presently applied to fulfill industry's need for d-c power. The conference will be held at the Morrison Hotel, Chicago, Ill., June 4-5, 1957.

This conference will be concerned principally with mercury arc rectifiers and the various metallic semiconductors including germanium and Silicon. It will be devoted to problems of design, application, and operation of complete conversion units utilizing these rectifying devices. The conference will be conducted in much the same manner as the joint Conference on Mercury Arc Rectifiers held in Pittsburgh, Pa., during the spring of 1952.

Preliminary plans for the conference were made at a meeting of the Executive Committee held in Chicago, Ill., on November 20, 1956. M. M. Morack, representing the Industrial Power Rectifier Committee, and Glen Ramsey, representing the Metallic Rectifier Committee will serve as cochairmen of the Executive Committee while J. N. Banky, representing the Chicago Section, will serve as conference chairman.

O. G. Villard, Jr., Receives Morris Liebmann Memorial Award

O. G. Villard, Jr. (AM '42), professor of electrical engineering at Stanford University, has been announced as the recipient of the Institute of Radio Engineers (IRE) Morris Liebmann Memorial Award ". . . for his contributions in the field of meteor astronomy and ionosphere physics which led to the solution of outstanding problems in radio propagation." The award is made annually to a member of the IRE for a recent important contribution to the radio art. The presentation will be made during the 1957 IRE National Convention.

COMMITTEE ACTIVITIES

EDITOR'S NOTE: *This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.*

General Applications Division

Committee on Land Transportation (E. A. Foster, *Chairman*; P. G. Lessmann, *Vice-Chairman*; J. C. Price, *Secretary*). The Standard No. 11 Subcommittee has been somewhat delayed in producing the final draft of the new rules to the Standards Committee because of last minute helpful comments rendered by the members of the Land Transportation Committee. These comments tended to produce a well rounded set of rules.

The 1957 Winter General Meeting has followed the same practice as in the past, i.e., presented subjects on heavy electric traction. These sessions, as in the past, have drawn a large number of AIEE members particularly in the railroad field from all over the country and including our Canadian members. It is felt that there is much in the foreign field of railway electrification to be learned by the American engineers, therefore the Committee recommends papers in this field and cordially invites authors throughout the world to participate in this endeavor.

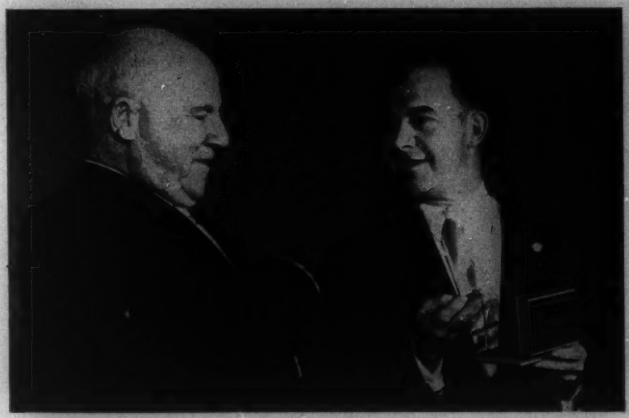
An attempt is being made to present papers of light traction subjects at the 1957 Summer General Meeting in Montreal, Que., Canada, a theme which proved fruitful at the 1956 Summer General Meeting in San Francisco, Calif. In the light traction field there is a trend towards the elimination of street railroad lines and continued interest has developed along the lines of rapid transit systems. Several of these systems are taking shape and producing results in various cities.

The High-Speed Train Resistance Subcommittee has not had the opportunity to make actual experiments due to the lack of funds. It is, however, collaborating with similar Committees of the American Society of Mechanical Engineers and the Association of American Railroads. Members of these Committees feel that by making known data available to all will do much to achieve the objectives of the group.

The Summer Session in San Francisco, Calif., was well attended, but the Committee Meeting needed greater support. The Session at the Fall General Meeting in Chicago, Ill., was as usual given good attention and the membership turnout at the Committee Meeting was most gratifying. As usual, the Land Transportation Sessions at the 1957 Winter General Meeting drew the greatest attention of the year and the Committee Meeting was well attended at which time plans were made for the future.

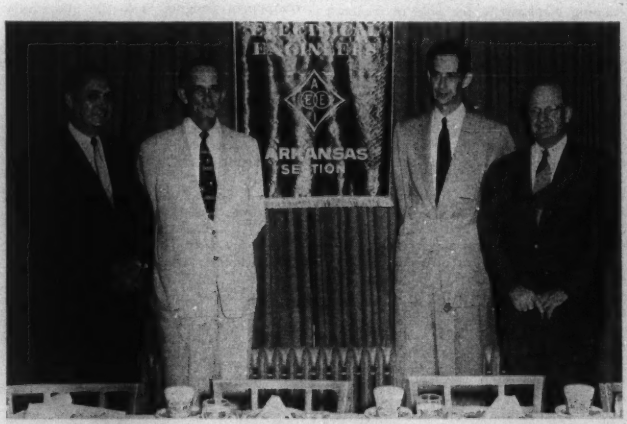
The New York, New Haven and Hartford Railroad is now receiving delivery on light weight high speed trains to operate between Boston, Mass., and Grand Central Terminal, New York, N. Y. The power for

J. S. Thompson Honored



J. S. THOMPSON *(left)*, **president, Federal Pacific Electric Co., received a watch on the occasion of the 50th anniversary of the company. Mr. Thompson (F '38) built the first high voltage switches produced by the Pacific Electric Manufacturing Co., a predecessor company, in 1906. Presentation of the watch was made by L. P. Shelley** *(right)*, **western regional manager for Federal Pacific Electric, at a dinner held in the Terrace Room of the Fairmont Hotel, San Francisco, Calif. Mr. Thompson received hearty congratulations from guests of honor including N. R. Sutherland, president of Pacific Gas & Electric Co.; L. W. Cole, chairman of the board and T. M. Cole, executive vice-president of Federal Pacific Electric.**

Arkansas Section Meeting



ONE OF THE RECENT monthly meetings of the Arkansas Section was devoted to the subject of upgrading the membership to the status of professional engineers and, in general, the ways by which this could be accomplished. Among those participating were *(left to right)* **Ward Goodman, chief engineer, Arkansas State Highway Department and president of the Arkansas State Society of Professional Engineers; V. E. Scott, secretary, Arkansas State Board of Registration for Professional Engineers; R. H. Boyd, Southwestern Bell Telephone Company, Section chairman; and R. J. Rhinehart, Arkansas Power & Light Company, national president of the National Society of Professional Engineers.**

these trains was supplied by three manufacturers and will have diesel engines as prime movers. When the trains reach the third rail territory of the New York Central Railroad, they will be equipped to continue into 42nd St. on third rail, 600 volt d-c power. This arrangement is unique in that it is the first time in electric traction history (throughout the world) that such an arrangement has been applied to high speed passenger trains.

Industry Division

Committee on Industrial Power Rectifiers (J. B. Pitman, *Chairman;* J. K. Dillard, *Vice-Chairman;* C. A. Langlois, *Secretary*). A working group of the Committee on Industrial Power Rectifiers has just completed the first revision of American Standard *C34*-1949 for Pool-Cathode Mercury-Arc Power Converters. This is the first revision of these standards since they were issued in 1949. The revisions have been approved by the membership of the Committee on Industrial Power Rectifiers and are now being submitted to the Standards Committee for their approval. If approved by the Standards Committee, they ultimately will be issued as an American Standard.

The 1957 plans for this Committee include a technical session to be held at the Summer General Meeting in Montreal, Que., Canada, in June.

There also will be a conference, sponsored jointly by the Committee on Metallic Rectifiers and this Committee, to be held in June. This will be the second conference of a series initiated in Pittsburgh, Pa., in 1952. The program, together with further details, will appear later.

Feedback Control Systems Component Specifications Subcommittee (Harold Chestnut, *Chairman;* R. G. Beadle, *Secretary*). Increasing emphasis in the field of feedback control systems is being placed on the systems aspects of the problem through analytical and computer studies. In many cases the systems have assumed such magnitude and complexity that an organization or group concerned with the system design may be somewhat removed from the design or detailed operation of the specific components involved. Inasmuch as the performance of the system is directly affected by the performance of its components, it is important that the methods for defining, describing, specifying, and testing feedback control system components receive proper attention. A step in this direction is being taken by the Definitions, Symbolisms, and Specifications Subcommittee of the Feedback Control Systems Committee of the AIEE. This work on control components is being done in conjunction with other AIEE committees as well as representatives from other technical socities such as the American Society of Mechanical Engineers (ASME), Institute of Radio Engineers (IRE), Instrument Society of America (ISA), American Institute of Architects (AIA), Society of Automotive Engineers (SAE), and American Standards Association (ASA).

For some time now representatives of ASA, as well as numerous of the technical societies concerned with feedback control systems have been working on the establishment of letter symbols for feedback control system terms. To accomplish this it has been necessary to establish clearly fundamental concepts. It was found that the best way to identify, define, and describe these concepts and set forth the relationships within a feedback control system was by means of a basic block diagram. The basic block diagram of a feedback control system and its associated definitions, symbols, rules for handling symbols, have been set forth in the proposed American Standard for Letter Symbols for Feedback Control Systems, *Y10.13-195*.

The Components Specifications Subcommittee has sought to build on the definitions, letter symbols, and block diagram ideas of *Y10.13-195* by extending those concepts which are pertinent into the specifications of various feedback control system components. For preliminary purposes, the control system components have been divided into such generic categories as signal elements, amplifiers, and power elements. Although some components may be used for more than one of these categories, there appear to be no objections to these general classifications.

The following is a summary of the objectives of Components Specifications Subcommittee:

1. For each component, the Subcommittee should add to and consolidate existing specifications to indicate the dynamic and other characteristics which the system designer needs.
2. If there are no existing specifications on a given component, the Subcommittee should work with the appropriate technical committee to prepare these specifications.
3. The methods for testing a component, where feasible, should be indicated by the Subcommittee so that the desired characteristics are properly obtained.
4. The Subcommittee should endeavor to educate both the system designer and the component designer as to the information required for component specifications and system design.

Currently, the Components Subcommittee is subdivided into small groups which are working on specific components as follows:

Synchros—L. F. Kazda, University of Michigan, department of electrical engineering, Ann Arbor, Mich.; M. Goldberg, Naval Department, BuOrd Code RES4D, Washington 25, D.C.

Gyros—P. Spink, Westinghouse Electric Corporation, Friendship International Airport, Baltimore 27, Md.; Robert Keeler, Minneapolis-Honeywell, Aero Division, Minneapolis, Minn.

Two-Phase Servo Motors—T. A. Westover, Servo Corporation of America, 2020 Jericho Turnpike, New Hyde Park, N.Y.; W. D. Jefferson, John Oster Manufacturing Company, 1 Main Street, Racine, Wis.

D-C Motors—R. G. Beadle, General Electric Company, Systems Application Engineering, Schenectady, N.Y.; L. F. Stringer, Westinghouse Electric Corporation, Metal Working Section, Pittsburgh, Pa.

Hydraulics—Warren Gaines, General Electric, aircraft products department, One River Road, Schenectady, N.Y.; A. A. Seleno, Vickers Incorporated, Administrative and Engineering Center, Detroit 32, Mich.

Transformers and Magnetic Amplifiers—D. D. Pidhayny, Ramo-Wooldridge, 5730 Arbor Vitae, Los Angeles, Calif.; H. C. Trueblood, Ramo-Wooldridge, 5730 Arbor Vitae, Los Angeles, Calif.

Hydraulic Components—E. S. Sherrard, Bureau of Standards, United States Department of Commerce, Washington 25, D.C.; D. C. Morin, Blackhawk Manufacturing Company, Industrial Hydraulic Control, Milwaukee, Wis.

Potentiometers and Pick-offs—C. W. Miller, Perkin-Elmer Corporation, Engineering and Optical Division, Norwalk, Conn.; J. A. Mitchell, Hughes Aircraft, Weapons Systems Development Laboratory, Culver City, Calif.

Accelerometers, Integrators, and Precision Power Supplies—A Paternini, Bell Aircraft, P. O. Box No. 1, Buffalo 5, N.Y.

Analog-Digital and Digital-Analog Devices—C. H. Baldwin, Westinghouse Electric Corporation, Youngwood, Pa.

As progress is made with the specifications of these various components, the members of the subcommittee may change in their components of interest.

Comments and suggestions for making the work of the Subcommittee more effective to systems designers and component manufacturers will be welcomed by the Subcommittee and should be addressed to Harold Chestnut, General Electric Company, One River Road, Schenectady, N.Y. Information relating to the work being done on specific elements should be directed to the individuals working on the specific components.

Power Division

Committee on Transformers (J. R. Meador, *Chairman;* D. L. Levine, *Vice-Chairman;* C. W. Miller, *Secretary*). At the Committee meeting in Toronto, Ont., Canada, on October 25, 1956, reports of the seven subcommittees were given and discussed.

Additional dielectric test tables for American Standard *C57* in the new format have been approved and sent to the Standards Committee. An analysis of the use of different BIL's for power and distribution transformers, 15 kv and below, has been prepared and probably will be published after being revised to take into account discussion at the Committee meeting.

Work is continuing on the preparation of a Guide for Impulse Testing. Switching surge tests and tests for corona, or ionization, are under discussion.

A Working Group on the Adequacy of Present Tests on Bushings has been very active, and a first draft of proposed changes has been prepared.

Progress is being made in the revision of the Guides for Loading Oil-Filled Transformers. This is an effort to make the Guides more usable. A separate group is working on a similar Guide for Dry-Type Transformers.

Additional progress was reported in several areas on the functional evaluation of insulation systems.

The Guide for the Maintenance of Insulating Oil has now been published for a one-year trial period, and comments and suggestions are solicited. A similar Guide for Askarel has reached the first-draft stage.

The West Coast Subcommittee continues its active interest in all of the varied projects of the other subcommittees.

Science and Electronics Division

Solid-State Devices Committee (J. P. Jordan, *Chairman;* S. J. Angello, *Vice-Chairman;* C. F. Spitzer, *Secretary*). Since the Solid-State Devices Committee acts largely as an administrative and review body for the activities in the subcommittees, this report will concern itself with their activities. These subcommittees are all joint with the Institute of Radio Engineers (IRE) and operate with dual chairmen. This organization has proved quite efficient in handling the technical needs of the AIEE where the scope of the technical activities is of equal importance to both AIEE and IRE.

Semiconductor Devices Subcommittee (Dr. S. J. Angello, *Chairman*—AIEE; Dr. J. M. Early, *Chairman*—IRE). This Subcommittee is active in sponsoring the Semiconductor Device Conference each spring and always sponsors at least one session at the Winter General Meeting. To date, three sections of the Semiconductor Standards have been completed and approved by the Standards Committee. These cover definitions of terms, general methods for test of semiconductor devices, and standards on point contact transistors for large signal application. Present activities include completion of standards on methods of test for junction semiconductor devices for large signal application, graphic symbols for semiconductor devices, and standards on semiconductor diodes for electronic uses.

Dielectric Devices Subcommittee (H. Epstein, *Chairman*—AIEE; C. A. Rosen, *Chairman*—IRE). This Subcommittee, with segments of the Subcommittee on Magnetic Devices, is organizing a Magnetics, Dielectrics, and Dielectric Devices Conference to be held at the Catholic University in Washington D.C., this spring. Because there is considerable feeling that such a conference will fill a definite need, it is planned to make this an annual affair if attendance at the first conference is large enough. In addition, this Subcommittee sponsors at least one session at the Winter General Meeting and usually a session at one other general meeting throughout the year. Considerable progress has been made on a glossary of terms and definitions and the Subcommittee expects to start work shortly on methods of test for certain selected devices.

Subcommittee on Magnetic Devices. This Subcommittee has been inactive since its formation and is at present being reorganized.

It has come to the attention of the parent Committee that a number of components used in electronic applications appear to have been neglected standardwise. A prime example is that of transformers for electronic applications and a Subcommittee is being organized under the Electronics Committee to initiate standardization activities in this field. However, a somewhat superficial review of other electronic components indicates the possibility that a similar situation exists for such components as varisters, thermistors, pulse forming networks, time delay relays, timing monitors, choppers, servos, syncros, magnetic memories, rotary switches, heads, telephone type filters. Comments by the Institute membership on the need for such standards would be appreciated.

Joint Division Committee on Automation and Data Processing, (G. W. Heumann, *Chairman;* I. S. Coggeshall, *Vice-Chairman;* R. S. Gardner, *Secretary*). One of the objectives of the Joint Division Committee on Automation and Data Processing is to give proper publicity to the work which is done by AIEE in this field. The word "automation" has a certain emotional appeal and activities devoted to this subject are drawing attention.

Publicizing automation has been overdone in some quarters and many engineers are getting tired of meetings which hit the high spots and get lost in generalities. What design, application, and operating engineers are looking for are technical programs devoted to the presentation of tangible technical information on automation tools and their application.

Many technical papers have been and will be presented at AIEE meetings which deal with automation problems. An example is the program of the Conference on Machine Tools held in Cincinnati, Ohio, October 22-24.

It is the belief of the Joint Division Committee that credit could be gained for AIEE if the contributions of its members toward automation problems were given proper publicity. The following steps have been suggested:

1. Feature the term "automation" in titles of papers wherever applicable.
2. Group papers dealing with automation subjects and use the term "automation" as a theme for technical sessions wherever applicable.
3. Properly highlight automation activities in Technical Committee reports to the Board of Directors and in "Committee Activities" appearing in *Electrical Engineering.*
4. Co-operate with the AIEE staff in giving proper recognition to automation activities in advance publicity for and reports on technical meetings and special technical conferences.

Bimonthly Publications

The bimonthly publications, *Communication and Electronics, Applications and Industry,* and *Power Apparatus and Systems,* contain the formally reviewed and approved numbered papers presented at General and District meetings and conferences. The publications are on an annual subscription basis. In consideration of payment of dues, members (exclusive of Student members) may receive one of the three publications; additional publications are offered to members at an annual subscription price of $2.50 each. Nonmembers may subscribe on an advance annual subscription basis of $5.00 each (plus 50 cents for foreign postage payable in advance in New York exchange). Single copies, when available, are $1.00 each. Discounts are allowed to libraries, publishers, and subscription agencies.

Membership in the American Institute of Electrical Engineers, including a subscription to this publication, is open to most electrical engineers. Complete information as to the membership grades, qualifications, and fees may be obtained from Mr. N. S. Hibshman, Secretary, 33 West 39th Street, New York 18, N. Y.

AIEE PERSONALITIES

G. W. Clothier (AM '36, M '42), manager, transformer department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., has been appointed manager of Allis-Chalmers motor and generator department. Mr. Clothier is an electrical engineering graduate of the University of Washington. He had been manager of Allis-Chalmers transformer department since 1947. Prior to that he had been engineer-in-charge of transformer sales for six years. He joined Allis-Chalmers in 1936. Mr. Clothier is a member of the Engineers' Society of Milwaukee. He served on the AIEE Committee on Transformers (1947-52).

Paul Hiza (AM '52), test manager, Testing Laboratory, International Business Machines Corporation (IBM), Endicott, N. Y., has been appointed assistant manager of the Testing Laboratory. Mr. Hiza studied mechanical engineering at the Cornell Extension School. He holds a technical diploma from the IBM School for the completion of 15 units of credit and has been an instructor in the Customer Engineering School. Mr. Hiza, who joined IBM in October 1936, began as a test operator in the Testing Laboratory. Later, he advanced to technician, then technical engineer, and in July 1952, became a technical assistant to the manager of the product testing department at IBM World Headquarters. In February 1954, he returned to Endicott, N. Y., as test manager in the Testing Laboratory.

P. M. Klauber (AM '42, M '49), chief administrative engineer, Solar Aircraft Company, San Diego, Calif., has been named chairman of the San Diego Section of the Society of Automotive Engineers. Mr. Klauber received an A.B. degree in engineering from Stanford University in 1937. He was employed for seven years by the General Electric Company in Schenectady, N. Y., and has been at Solar since 1946. He is a member of the American Society of Mechanical Engineers and the Institute of Aeronautical Sciences.

J. E. Lagerstrom (AM '47, M '54), assistant professor of electrical engineering at Iowa State College, Ames, Iowa, has been named assistant to the dean of engineering at that college. He began his new duties January 1. A member of the faculty since 1946, Mr.

Lagerstrom will continue with some teaching duties. Born in Galesburg, Ill., Mr. Lagerstrom lived in Omaha, Neb., from 1936 to 1942, and took his first two years of undergraduate work at the University of Omaha. In 1944, he received the B.S. degree in E.E. from Iowa State College, and in 1951 received the M.S. degree. He is a licensed professional engineer in Iowa. He has served both as secretary and as chairman of the AIEE Iowa Section. He is also a member of the honorary societies of Eta Kappa Nu (electrical engineering), Tau Beta Pi (engineering), Phi Kappa Phi (scholarship), Pi Mu Epsilon (mathematics), and Knights of Saint Patrick (engineering activities). During World War II, Mr. Lagerstrom served from 1944 to 1946 with the Air Force where he was a *B-29* tail gunner. He has served on the AIEE Committee on Transmission and Distribution (1952-57).

George Friedl, Jr. (M '38), vice-president and director of advanced planning, Link Aviation, Inc., has joined Litton Industries as a vice-president. A graduate of Cooper Union Institute of Arts and Sciences, School of Engineering, where he received a B. S. degree in 1928 and an E. E. degree in 1931, Mr. Friedl also took post-graduate work at Columbia University and at New York University. Associated with General Precision Equipment Corporation (GPE) from 1937 to 1950, he was president and director of the GPE subsidiary, Librascope, Inc., before joining Link Aviation as works manager in 1953. He was elected vice-president of manufacturing for Link in 1954, and vice-president and director of planning in January 1956. Prior to his association with various divisions of GPE, he had been associated with the Western Electric Company from 1928 to 1937 in both engineering and industrial relations, in the United States and in England. During World War II, Mr. Friedl was in the U. S. Navy, serving at the Naval Research Laboratory in Washington, D. C.

OBITUARIES

Henry Vander Bogert Erben (M '43), retired vice-president of the General Electric Company, died recently at the age of 58. Mr. Erben was born in Schenectady, N. Y. He was graduated from Yale University's Sheffield Scientific School in 1919 with a degree in mechanical engineering. He joined the General Electric Company in 1920 as a student engineer on the Test Course. In 1923, he was transferred to the Apparatus Division of the central station department. In 1939, after successive promotions, he was appointed assistant manager of the central station department and two years later he was made general manager. In 1948, Mr. Erben was elected vice-president and general manager of the apparatus department. He was named executive vice-president in 1951 and in 1954 he was appointed to head the newly formed Distribution Group.

Otto Lumley Giersch (M '40), system planning engineer, Duke Power Company, Charlotte, N. C., died recently at the age of 55. Mr. Giersch was born in Raleigh, N. C. He was graduated from the University of North Carolina with a B.S. degree in E.E. He was employed by the General Electric Company until 1928 when he became associated with the Duke Power Company as relay engineer. He was advanced to the position of assistant planning engineer and later to planning engineer. Mr. Giersch served on the following AIEE Committees: Protective Devices (1951-53), Carrier Current (1951-52), and System Engineering (1955-57).

Howard G. Krohn (AM '51), division engineer, Commonwealth Edison Company, Public Service Company Division, died recently. Mr. Krohn was born in Hebron, Wis., December 10, 1901. He was graduated from the University of Wisconsin in 1924 with a B.S. degree in E.E. In 1926, he joined the Public Service Company of Northern Illinois as a field engineer. Later, he held the positions of engineer, senior engineer, assistant division engineer, and division engineer. Mr. Krohn was a registered professional engineer in the State of Illinois and a member of the Western Society of Engineers.

Terryl B. Montgomery (AM '36, M '41, F '49), chief engineer, electrical application department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis., died recently at the age of 56. Mr. Montgomery was an electrical engineering graduate of the Georgia School of Technology. He had been closely associated with many of the foremost developments in the field of automatic control since his first association with Allis-Chalmers in 1925. Although in recent years Mr. Montgomery had concentrated on steel mill control, his patents range from dust collector control to automatic waterwheel generator loading and included inventions for variable WR^2 compensation on tension regulators, reel tension control for temper pass mills, and reversing cold mill control. His affiliations included the Association of Iron and Steel Engineers. Mr. Montgomery served on the following AIEE Committees: Industrial Control (1949-50); Mining and Metal Industry (1946-57, chairman 1949-51); Standards (1949-50); Technical Program (1949-50); and Industry Division (1949-51).

Ernest Haskie Ownbey (AM '49, M '55), radio engineer for the Tennessee Valley Authority (TVA), died recently at his home in Chattanooga, Tenn. He was employed by TVA in 1936 and remained with them until his death, except for a period of time in which he served in the U. S. Navy during World War II. Mr. Ownbey was chief of the Radio Section of the Communication Engineering Branch and was responsible for the engineering of the 700-mile microwave system in use by TVA. He was a licensed engineer in Tennessee and was active in local AIEE affairs.

MEMBERSHIP

Recommended for Transfer

The Board of Examiners at its meeting of December 20, 1956, recommended the following applications for transfer. Any objections to these transfers should be filed at once with the secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Member

BaHli, F., acting director, Union of Burma Atomic Energy Center, Kanbe, Rangoon, Burma

Benda, H. W., manager, engg. & construction, Iowa Southern Utilities Co., Centerville, Iowa.
Boughton, J. K., supervisor, instrument maintenance, Goodyear Atomic Corp., Portsmouth, Ohio
Carter, A. G., section engineer, Canadian Westinghouse Co., Hamilton, Ont., Canada
Clark, R. A., Jr., supervisory engineer, Westinghouse Electric Corp., Pittsburgh, Pa.
Cunningham, C. F., inspection & testing supervisor, Westinghouse Electric Corp., Cincinnati, Ohio
Faytinger, R. D., sales engineer, General Electric Co., Pittsburgh, Pa.
Flowers, R. G., sales engineer, General Electric Co., Shreveport, La.
Goldnand, W., engineer-in-charge, Powercraft Corp., St. Louis, Mo.
Gonzales, E., electrical engineer, Guy B. Panero, New York, N. Y.
Hunter, W. E., engineer & manager, Construction Div., Bryant Electric Repair Co., Inc., Gastonia, N. C.
Janney, D. B., power distribution supt., Union Carbide Nuclear Co., Oak Ridge, Tenn.
Kelly, H. A., chief engineer, Wheeling Stamping Co., Wheeling, W. Va.
Klager, W. K., Cutler-Hammer, Inc., Milwaukee, Wis.
Lapin, S. P., market development engineer, Motorola, Inc., Chicago, Ill.
Lipman, K., electrical engineer, Westinghouse Electric Corp., Pittsburgh, Pa.
Mahler, L. W., senior electrical engineer, Chemical Plants Div., Blaw-Knox Co., Pittsburgh, Pa.
MacCarthy, H. P., senior engineer, Florida Power & Light Co., Miami, Fla.
Nelson, E. A. A., Jr., engineer, Interstate Oil Pipe Lir Co., Shreveport, La.
Patterson, L. A., transmission development engineer, British Columbia Power Comm., Victoria, B. C., Canada
Persson, J. A., research engineer, Metals Research Laboratories, Niagara Falls, N. Y.
Pillmore, G. A., application engineer, General Electric Co., Milwaukee, Wis.
Pohlman, J. C., chief electrical engineer, Hubbard & Co., Chicago, Ill.
Priester, F. A., electrical engineer, U. S. Navy Mine Defense Lab., Panama City, Fla.
Qureshi, M. H., assistant professor, The Punjab College of Engineering & Technology, Moghalpura, Lahore, Pakistan
Schuh, N. F., Jr., supervisory engineer, aircraft equipment dept., Westinghouse Electric Corp., Lima, Ohio
Shubert, W., assistant principal electrical engineer, Blaw-Knox Co., Pittsburgh, Pa.
Therkelsen, E. B., research engineer, Willow Run Lab., University of Michigan, Ypsilanti, Mich.
Underwood, W. H., load group electrical engineer, Long Island Lighting Co., Hicksville, N. Y.
Vitkus, A., senior research engineer, Hubbard & Co., Chicago, Ill.
Wenk, L. E., owner, Wenk Electric Service, Bossier City, La.
Williamson, D. R., design engineer, Georgia Power Co., Atlanta, Ga.
32 to grade of Member

Applications for Elections

Applications for admission or re-election to Institute membership in the grade of Member have been received from the following candidates, and any member objecting to election should so notify the Secretary before February 25, 1957 or April 25, 1957, if the applicant resides outside of the United States, Canada or Mexico.

To Grade of Member

Alexander, P., engineer, Georgia Power Co., Atlanta, Ga.
Bachynski, N., branch manager, Reliance Electric & Engineering Co., Appleton, Wis.
Browne, W. J., project engineer (electrical), Universal Atlas Cement Co., New York, N. Y.
Craiglow, L. H., supervisory electronics engineer, Griffiss Air Force Base, New York
Dean, N. J., member of Technical Staff, The Ramo-Wooldridge Corp., Los Angeles, Calif.
Fingerle, W., president, Budelman Radio Corp., Stamford Conn.
Hjortsvang, H. I., applications engineer, Lenkurt Electric Co., San Carlos, Calif.
Jackel, A. P., supervising design engineer, Union Switch & Signal Div., Westinghouse Airbrake Co., Pittsburgh, Pa.
Jerson, T. J., motor project engineer, Apex Elec. Mfg. Co., Sandusky, Ohio.
Kool, S. E., supervising design engineer, Electro Metallurgical Co., a Div. of U.C.C., Niagara Falls, N. Y.
Manley, F. A., staff engineer, Stromberg-Carlson Co., Rochester, N. Y.
McLaughlin, manager customer sales, General Electric Co., Schenectady, N. Y.
Moss, K. S., project engineer, American Smelting & Refining Co., Corpus Christi, Tex.
Pearce, J. G., engineering group head, Stromberg-Carlson Co., Rochester, N. Y.
Pittman, P., field engineer, Earl Lipscomb Associates, Dallas, Tex.
Pollock, S. I., electrical engineer, Dept. of Interior, U. S. Bureau of Reclamation, Denver, Colo.
Raynor, W. R., project manager, Stevens & Wood Incorp., New York, N. Y.
Subrahmanyam, D. K., senior technical executive, National Electrical Industries, Ltd., Bombay, India
Thompson, G. J., engineer, N. Y. Naval Shipyard, Brooklyn, N. Y.
Weybrew, T. L., section manager, Westinghouse Electric Corp., Pittsburgh, Pa.
White, J. E., Jr., electrical engineer, B. O. Vannort Engineers, Inc., Charlotte, N. C.
21 to grade of Member

ELECTRICAL ENGINEERING EDUCATION

AIEE in Ohio Northern University

THE STUDENT BRANCH of the AIEE at Ohio Northern University, Ada, Ohio, was founded in 1912. It enjoys the dual distinction of being both the oldest technical society on the campus and the first AIEE Student Branch in the State of Ohio.

At the time of its initial organization, the electrical engineering department contained only eight students. Today, the department contains 89 students of whom 60 are members of the AIEE Student Branch.

The Engineering College at Ohio Northern University, which is fully accredited by Engineers Council for Professional Development, places a great deal of emphasis on student participation in organizations of this type.

The chapter meets once a month for regular meetings and at other times for special meetings in order to supplement the material offered in the regular curriculum.

Foundation Announces Second Series of Computer Center Grants

THE SECOND in a series of grants in support of computation centers and research in numerical analysis has been announced by A. T. Waterman, director of the National Science Foundation. Grants totaling $230,000 were awarded as follows: Cornell University, $50,000; University of California (Berkeley), $50,000; University of Pennsylvania, $70,000; Princeton University, $40,000; and Stanford University, $20,000.

The Cornell grant is designed to support the expanded research facility at the University Computing Center which was used by 26 departments and schools during 1954-55. Those which used at least 100 hours of machine time were: aeronautical engineering, family relations, industrial and engineering administration, industrial and labor relations, mathematics, psychology, and plant breeding. The University of Rochester has used the Center a total of 400 hours. It is expected that the Center will extend its services to other institutions located in the region.

The University of California grant was made to help develop a computer laboratory on the Berkeley campus. A variety of scientific research under way at Berkeley requires massive computation and includes such fields as engineering, astronomy, genetics, education, physics, mathematics, statistics, and psychology.

Within the University of Pennsylvania, the computer center will be used by the departments of mathematics, physics, chemistry, and astronomy, the Moore School of Electrical Engineering, and the School of Medicine. Neighboring institutions which expect to participate in the center are Bryn Mawr College, University of Delaware, Swarthmore College, Temple University, and Haverford College.

John von Neumann, now a member of the Atomic Energy Commission, designed the original high-speed computer now at Princeton University which became the prototype for all large machines with internally stored programs. Research on stellar evolution and nuclear physics will continue to employ the machine, while further use is related to the design, construction, and operation of a 3 billion volt proton accelerator now under way at Princeton University.

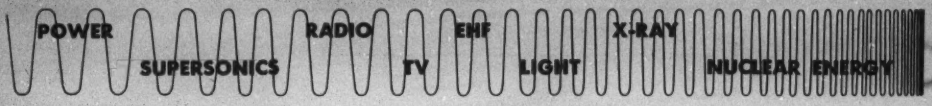
The grant to Stanford University will support numerical analysis, application of computing machine methods to scientific problems, and training of personnel in the techniques of machine computing. Fields in which the computer at Stanford University has had wide use include statistics, mathematics, physics, engineering, and biochemistry.

The first in this series of Foundation grants was announced September 10, 1956. At that time, grants totalling $135,500 were awarded as follows: California Institute of Technology, $38,000; Massachusetts Institute of Technology, $30,000; Oregon State College, $20,000; University of Washington, $17,500; and University of Wisconsin, $30,000.

The Foundation's program is designed to strengthen basic research in a number of fields by providing research investigators access to computing facilities. Only a few large computing centers around the country are available for basic research problems and these generally on a part-time basis only. Most computers are busy on a round-the-clock schedule on industrial problems and problems related to defense contracts. The general-purpose university computing laboratory does not have sources of support for basic research at present. Foundation assistance will help to establish or strengthen such general-purpose research laboratories.

Foundation support for various aspects of computer research and training has been worked out with the advice and assistance of an Advisory Panel for University Computing Facilities, headed by John von Neumann, commissioner, Atomic Energy Commission. Other members of the panel, who represent a number of disciplines, are: H. L. Anderson, Institute for Nuclear Studies, University of Chicago; J. G. Charney, School of Mathematics, Institute for Advanced Study; G. M. Clemence, director, *Nautical Almanac*, U. S. Naval Observatory; J. O. Hirschfelder, department of chemistry, University of Wisconsin; R. E. Meagher, department of physics, University of Illinois; P. M. Morse, department of physics, Massachusetts Institute of Technology; J. B. Rosser, department of mathematics, Cornell University; Martin Schwarzschild, department of physics, Princeton University; Edward Teller, department of physics, University of California; W. H. Munk, Scripps Institution of Oceanography; and S. M. Ulam, Los Alamos Scientific Laboratory.

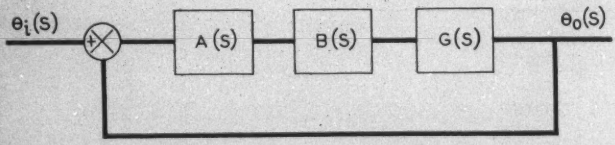
Electrical Engineering Education



Graphical Solution of Servo Problems

E. D. SCOTT

MANY SERVOMECHANISMS can be represented by the block diagram shown below with *A*'s and *B*'s equal to 1. It is frequently necessary to extend the frequency bandwidth over which the output is approximately equal to the input and to decrease the difference between the input and output of the servomechanism by modification of the system. This may be accomplished by inserting lag and lead networks for *A*'s and *B*'s in the block diagram, respectively. The design problem is then one of determining the circuit parameters of the lead and lag networks.



It is possible to determine the design by analytical methods, but graphical methods are usually employed because the solution of the problem is one of trial and error, and the graphical methods are less time consuming. (Principles of Servomechanisms, G. S. Brown, and D. P. Campbell.)

Mr. Scott is a member of the Texas A&M Joint AIEE-IRE Student Branch

By the graphical method the modified system can be made to satisfy three specifications: the resonant frequency, the magnitude of the output-input ratio at the resonant frequency, and the static error coefficient. The author has developed an analytical method of solution which can be conveniently programmed for a digital computer. The rapid operation of the computer eliminates the principal cause for the use of the graphical method and enables a more precise design to be made. In addition to the three specifications mentioned, the method requires that the phase angle of the output-input ratio at resonance be specified. The digital computer is programmed to give a complete family of values for the parameters of the lead and lag networks, enabling the designer to select the most desirable set. On a test problem, a set of parameter values was developed in less than one minute.

The author intends to submit a complete description of the analytical method of solution at a later date.

RPI Installs Cobalt-60 Swimming Pool Reactor

THERE IS a new swimming pool reactor at Rensselaer Polytechnic Institute (RPI), which has a small radioactive cobalt pipe at the bottom emitting hundreds of billions of lethal gamma rays every second.

The cobalt-60 swimming pool reactor is one of some 20 similar installations throughout the country. It is designed for safe tests of the effects of gamma rays on biological and chemical specimens; in the sterilizing of foods and sealed drugs; and in the treatment of plastics, synthetic fibers, and many other industrial materials.

Research scientists of the Institute have started using the facility. Their initial experiments have dealt with the effect of the radiation on viruses and enzymes. Sterling-Winthrop Research Institute, which had provided $10,000 of the pool's capital cost and is contributing $15,000 toward operating expenses for the first three years is planning an extensive program of experiments. Both chemical and biological specimens will be exposed to the cobalt rays, says Dr. F. C. Nachod, head of Sterling-Winthrop's physical chemistry section and an adjunct professor of chemistry at RPI.

Extensive use of the facility by industrial laboratories and by hospital and medical group researchers is foreseen by Dr. V. L. Parsegian, professor of nuclear science at the Institute. Dr. Parsegian, a leader in proposing the new facility for the Institute, guided the plans for the pool and its construction. Its use is administered by the department of biology.

With growing demand for its services, the power of the cobalt-60 swimming pool can be increased from the 970 curies of the present source to as much as 5,000 curies by the installation of additional cobalt pipes and specimen holders at the bottom of this same pool. Each cobalt source has a radiation half-life of 5.3 years.

The cobalt pipe, recently installed at RPI after a truck trip from the Brookhaven National Laboratories on Long Island, N.Y., was prepared by the subjection of the pure cobalt to the bombardment of neutrons in a Brookhaven nuclear reactor. It traveled to Troy, N.Y., in the center of a 4,000 pound pig of lead. This pig was removed by crane from the truck and lowered to the bottom of the 14 feet of water in the pool. Then the glowing pipe of cobalt was removed by remote control and placed in the center cylinder of the sheet brass holder.

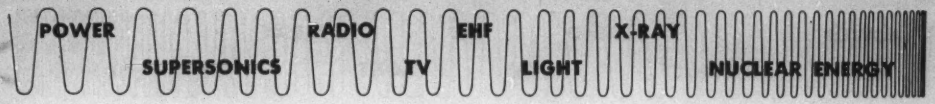
The cobalt pipe is about 13 inches high and about 2 inches in diameter. The round pipe, less than a quarter inch thick, is totally encased in a thin sleeve of stainless steel. The cobalt source stands snugly in the center recess of the brass holder. The center of the pipe stands open for the insertion of a carrier holding specimens to be subjected to the intensified radiation from the cobalt all around it.

When it is dark in the laboratory the top of the cobalt pipe glows with a blue-white intensity which spreads out over the top of the brass holder.

The brass holder, slightly deeper than the 13-inch cobalt pipe, is watertight and full of air. It has a diameter of three feet and contains a variety of open cylinders into which round and watertight cases of thin copper can be lowered to force out the water and expose the enclosed specimens to the varying dosages of gamma rays. Intensity of the rays decreases by a half for approximately each five inches of distance from the radiation center.

Any living organism dies from brief exposure close to the cobalt pipe. A few of the gamma rays escape through the top of the pool but less of them than are normally in the atmosphere. The shielding water is 4 feet deeper than the 10-foot depth regarded as adequate protection.

The concrete pool, six feet wide and eight feet long, is sunk in the rock beneath the laboratory adjoining the parking lot north of Sage Ave. The operator may stand on a movable metal bridge across the top and use cables to lower the specimen cases into the open cylinders of the holder. Four of the open cylinders receive cases 8 inches in diameter, 4 receive cases 5 inches in diameter, and 17 are 3 inches in diameter.



One of the cables from the top connects with a trapdoor in the bottom of the pool and this leads to a narrow shaft of water extending 17 feet below the bottom of the cobalt swimming pool. The cobalt pipe will be lowered into this bottom shaft when it is desired to empty the reactor and put in fresh water. The water in the pool is not contaminated by the gamma ray radiation but it could be replaced if by any chance some fissionable material should be brought into the pool on the metal shell of a radiation source.

When the cobalt pipe arrived at the laboratory recently, the transfer from the big lead pig required some delicate work. A screwdriver 17 feet long was used to take out the large screw at the top of the pig. Another 17-foot tool with an expanding unit on the end, was used to remove a plug over the cobalt pipe. Then the expanding unit was lowered into the pipe and it was raised slowly out of the pig and inserted into the center cylinder of the brass holder.

Six Universities Selected for Expanded ORSORT Program

S. R. Sapirie, manager of the Atomic Energy Commission's Oak Ridge (Tenn.) Operations, has announced that six universities have been selected for participation in a program designed to double the number of nuclear reactor specialists trained each year at the Oak Ridge School of Reactor Technology (ORSORT).

The universities selected from among 44 which submitted proposals to the Commission in October were: Carnegie Institute of Technology, Pittsburgh, Pa.; Case Institute of Technology, Cleveland, Ohio; Northwestern University, Evanston, Ill.; University of California, Los Angeles, Calif.; University of Florida, Gainesville, Fla.; and Union College, Schenectady, N. Y.

Mr. Sapirie said that two-year contracts will be negotiated with the universities to provide for concentrated courses of study designed to develop specific proficiency in chemistry, mathematics, physics, and engineering for students accepted for ORSORT. All proposals received from colleges and universities were satisfactory and the six selected were on the basis of being the most suitable to meet the present short-term needs of the ORSORT program.

Under the expanded ORSORT program, the first six months of the one-year course will be given at the participating institutions and the remaining six months at the Oak Ridge National Laboratory, which operates the school for the Commission. This arrangement will permit two classes of 120 students each to be trained each year. Currently, only one class of 120 students can be accepted annually for ORSORT because of limited facilities at the Laboratory.

Mr. Sapirie pointed out that taking advantage of the educational experience of the academic institutions will permit a total of 480 scientists and engineers to be trained during the two-year period to meet in part the growing personnel demands by Government and private industry for nuclear reactor programs.

The university phase of the program will cover unclassified material, but the later ORSORT phase will cover classified subjects and will be concentrated so as to take advantage of the unique facilities and the latest technology available at Oak Ridge.

Each of the universities will be assigned a minimum of 20 students beginning in February 1957. Successive classes totaling 120 students each will be assigned to the six universities in August 1957, February 1958, and September 1958.

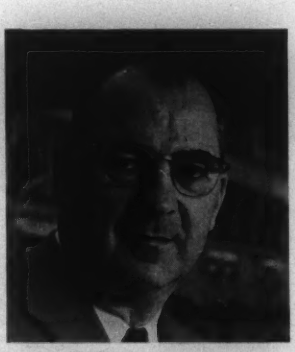
Applicants for ORSORT may state a first and second preference for the institution which they wish to attend for the first phase of training. The applicant's preference will be honored where possible, although applicants may be assigned to any of the six institutions.

Applicants for ORSORT are sponsored by industrial firms or Government agencies. Minimum academic requirements for admission are a bachelor's degree in science or engineering, a course in ordinary differential equations, and an above-average scholastic record. Students for ORSORT are selected by a committee which includes representatives from the Commission, the Laboratory, and the participating institutions.

The charge for the Oak Ridge portion of the program now will be $1,500. The fees for the university portion of the program will vary with the institution attended, and are designed to cover the total cost of the program at the particular institution. The range of fees to be charged by the universities will be $1,000 to $1,500. These fees will be paid directly to the schools in the form of tuition by the student or the sponsoring organization. Currently, the total charge for the ORSORT course is $2,500.

More than 450 students have been graduated from ORSORT, which was established in 1950 at Oak Ridge National Laboratory, operated for the Commission by Union Carbide Nuclear Company.

An Electrical Engineer in Industry



A. C. MONTEITH (AM '25, M '40, F '45), vice-president, Apparatus Products Division, Westinghouse Electric Corporation, Pittsburgh, Pa.

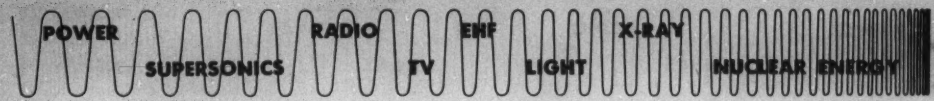
"The young engineer entering the world of commerce and industry today is presented with opportunities in number, breadth, and depth never encountered by other generations entering our profession. As a matter of fact, your services are actively solicited. Most of you won't have to 'look' for a job.

"And in a way, this brings me directly to the heart of the short message I want to give to you. It is this: Don't lose your perspective because of the tremendous demand for your services. While getting a job today is ridiculously easy, making good in it is just as hard and exacting as it ever was; perhaps even more so! Many factors contribute to the degree of success of the individual engineer, and these have been enumerated many times.

"Active support and participation in your professional society is one factor sometimes overlooked. The opportunities provided by AIEE for professional growth and recognition are many. I can speak directly from personal experience on this point. In my company we support the doctrine that every engineer who considers himself to be a professional man has the obligation to support at least one technical society."

Dr. Monteith's formal education was received at the Queen's University of Kingston, Ontario, Canada, where he achieved his degree in electrical engineering. There he won the Governor's Medal, awarded to the engineering student receiving the highest grades during his junior and senior years. In October of 1948, he was honored by his Alma Mater when they presented him with the degree of LL.D.

Dr. Monteith's extensive engineering and business career began in 1923 when he joined Westinghouse at East Pittsburgh, Pa., as a graduate student on the firm's training program. The following year he was assigned to the central station engineering department where he became an



expert in power station auxiliaries, power system transmission, distribution, and related fields. He became manager of the central station engineering department in 1938. While holding this position, he was awarded the Westinghouse Order of Merit in 1940, the highest honor which the company can bestow on an employee.

In 1948, he was elected vice-president in charge of engineering and research, and in the same year was named chairman of the Westinghouse Educational Foundation. Dr. Monteith assumed his present executive position of vice-president, Apparatus Products Divisions, in August 1955.

He has long been a member of the AIEE and served as President for the 1954-55 year. He has served as a national director, and has been chairman of several of the Institute's committees. He is also a past-chairman of the Pittsburgh Section. His other association activities include membership in the American Society of Mechanical Engineers, which organization bestowed upon him their highest award when he was elected an Honorary Member in 1953. He is a member of Tau Beta Pi, national honorary engineering society, and an honorary member of Eta Kappa Nu, engineering fraternity.

Dr. Monteith has received an honorary D.Sc. degree from Lafayette College, Easton, Pa., and an honorary D.Eng. degree from the Drexel Institute of Technology, Philadelphia, Pa.

He is the author of numerous technical papers and articles concerning power system problems, and is a coauthor of the Electrical Transmission and Distribution Reference Book, widely used as an authoritative reference by both the power industry and the colleges of America.

Lehigh University Adopts Engineering Mechanics Program

The establishment of a curriculum in engineering mechanics starting in September 1957 leading to a degree of B.S. in engineering mechanics by Lehigh University has been announced by Dr. H. A. Neville, provost. This will bring to 10 the number of curricula in the College of Engineering of which L. V. Bewley is dean.

The faculty also approved three new courses in mechanics. Advanced Mechanics of Materials will be an introduction to two-dimensional theory of elasticity, theories of failure, bending and torsion of prismatic bars, principles of indeterminate analysis, and instability.

A course entitled "Mechanics of Continua" will be offered in two parts. Incorporated will be fundamental principles of the mechanics of deformable bodies, equilibrium and compatibility equations, energy principles, potential function, conformal representation, applications to the solution of problems in elasticity, hydrodynamics, and plasticity.

Dean Bewley pointed out that this will be a highly scientific curriculum. It conforms to the recommendations of the American Society for Engineering Education for more basic and fundamental approaches in engineering.

In describing the new offerings, Dean Bewley said the curriculum is especially designed for high grade analytical work in aircraft, automotive, and similar industries. He said that it is significant in that twice as much mathematics will be required as in other engineering curricula.

Students enrolled in this curriculum will start with the uniform program for engineering freshmen. The sophomore year will be devoted to courses in heat, sound, and light; engineering materials, calculus, economics, physics, and statics.

Group options in the junior and senior years are intended to enable the student to correlate his theoretical training with engineering practice in a specific field or to carry a more intensive study of mathematics. These group options will be in structural engineering, machine design, fluid flow, metallurgy, and mathematics.

Two-Year Study of Physical-Science Teaching Begun

A. T. Waterman, director, National Science Foundation, has announced award of a grant by the Foundation of $303,000 to the Massachusetts Institute of Technology, (MIT), Cambridge, Mass., to support a two-year study of physical-science teaching in secondary schools.

Some of the foremost physical scientists of the United States will serve on an MIT-sponsored committee, under the direction of J. R. Zacharias, professor of physics at MIT. The committee will make an intensive effort to improve presentation of high-school subject matter in the physical sciences. The group will examine all possible means of improving instruction in the physical sciences, realizing that this may lead to preparation of new textbooks, new laboratory manuals, new experimental equipment, new teaching techniques, and extensive use of films. They will be aided by leading members of the faculties of the California Institute of Technology, the University of Illinois, and Cornell University, as well as by representatives from the Bell Telephone Laboratories, who will attempt to outline materials necessary to accomplish the objectives of the project.

Dr. J. R. Killian, Jr., president of MIT, will be chairman of a larger group, composed of scientists, high-school administrators and teachers, representatives of state departments of education, and others, to advise, and make recommendations on problems of acceptance and distribution.

"The Foundation has long realized the need of teachers of secondary-school science for better textbooks, better materials, better instruction techniques," said Dr. Waterman in commenting on the MIT grant. "Teachers need up-to-date tools to do a competent teaching job. We believe, however, that we must make a broad attack on the problem, rather than approach it on a bits-and-pieces basis."

"The Foundation is assured," Dr. Waterman said, "that leading United States citizens in the field of education will be available for this important job—including, importantly, high-school teachers of physical science, and others in the fields of science, industry, and communication. Their goal is to devise a practical program which will improve the general level of science teaching, better prepare students for advanced work while not neglecting the values of general education, and attract more talented students to science as a career."

Among the group who have been associated with Prof. Zacharias in planning the project are such outstanding men as Vannevar Bush, president (ret.), Carnegie Institution of Washington; Henry Chauncey, president of Educational Testing Service, Princeton University; N. H. Frank, chairman of the physics department, MIT; F. L. Friedman, associate professor of physics, MIT; E. H. Land, Institute professor, MIT, and president and director of research, Polaroid Corporation, Cambridge, Mass.; Morris Meister, principal, Bronx High School of Science, N. Y.; Walter Michels, head of the science department, Bryn Mawr College; Edward Purcell, professor of physics, Harvard University; I. I. Rabi, Institute professor (visiting), MIT, and professor of physics, Columbia University.

Applications Now Accepted for AEC Fellowship Program

Applications are now being accepted for participation in the program of special fellowships in nuclear energy technology recently announced by the U. S. Atomic Energy Commission (AEC). The program has been established by the AEC to encourage qualified students to pursue courses of study in the fields of nuclear science and engineering. The fellowships are part of the AEC general program of assistance in the field of education, with the goal of lessening the manpower shortage in the area of nuclear energy technology.

The program will be administered by the Oak Ridge Institute of Nuclear Studies (ORINS), which now administers the special fellowships in radiological physics, the special fellowships in industrial hygiene,

and the ORINS graduate fellowship program for the AEC.

The fellowships are open to students with the bachelor's degree in engineering, chemistry, mathematics, or physics, who have completed a course in ordinary differential equations. Applicants must be United States citizens and be granted fellowship clearance by the AEC. Before fellowship appointments become effective, the applicant must be accepted as a graduate student, as a candidate for a master's degree, by an institution offering the necessary program of study.

The AEC is making a selection of programs of graduate study which meet the fellowship requirements. Institutions offering these programs will be listed with the application forms and applicants may choose their institutions from this list.

The program of study will include the following courses: nuclear physics, nuclear reactor analysis, nuclear reactor technology, radiochemistry and reactor materials, and advanced mathematics.

Fellowships will be awarded for one year's study. The fellowship award carries a basic stipend of $1,800, with an additional allowance of $350 for a spouse and $350 each for a maximum of two dependent children. The award also includes the payment of normal tuition, required fees, and a travel allowance of six cents per mile for the fellow (not dependents) from his place of residence (or application) to his university. Fellows are expected to devote all their time to study and research and may not engage in work for remuneration, or receive aid from another scholarship, fellowship, or similar grant during the term of this fellowship.

Applications for the Nuclear Energy Technology Fellowship may be obtained from the Fellowship Office, Oak Ridge Institute of Nuclear Studies, Post Office Box 117, Oak Ridge, Tenn. Completed applications, supporting letters of reference, and transcripts must reach ORINS not later than February 15, 1957, to ensure consideration. The final selection of candidates will be made by a Fellowship Board, and appointments will be announced about March 15, 1957.

Model Reactor at VPI Aids Nuclear Training Program

An electronically controlled model reactor, which precisely imitates the behavior of an actual reactor, is now in use for training and research at one of the nation's leading technical colleges. Known as a nuclear reactor simulator, the device is the latest means to help reduce the critical shortage of trained nuclear scientists and engineers and to facilitate research on industrial applications of atomic energy.

The nuclear reactor simulator is in operation at the atomic energy laboratory of Virginia Polytechnic Institute (VPI) where 20 graduate engineers are taking a newly inaugurated course in nuclear engineering. It is the first equipment of its kind to be installed in any educational institution. Developed by Leeds and Northrup Co. (L&N), Philadelphia, Pa., manufacturer of automatic instruments and controls, the simulator consists essentially of an electronic analog computer, a control console, and a model of a reactor core. The computer continuously solves the differential equations that represent the kinetic operation of a nuclear reactor. The control rods in the model core respond to the signals from the computer so that the operator can see the effects of his control actions.

The VPI simulator is similar to a unit which L&N built last year for Atomic Energy Commission use at the "Atoms for Peace" Conference, Geneva, Switzerland. Along with a newly built natural uranium exponential reactor, the simulator at VPI is being used for training graduate engineers in nuclear theory and operation as well as for many kinds of research for all industries interested in atomic energy.

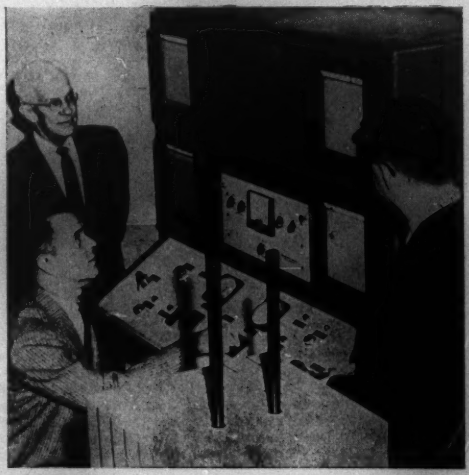
X-Ray Diffraction Data Offered at Special Prices

The American Society for Testing Materials (ASTM) is now offering to colleges and universities at 80 per cent discount from the list prices the X-ray diffraction Data Card File published by ASTM. Discount is offered on the basis that the card file will be used for classroom instruction. A certification to this effect will be necessary in order for the special discount to apply.

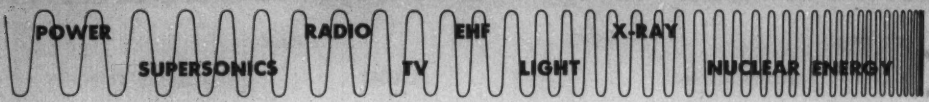
ASTM acts as business agent for the Joint Committee on Chemical Analysis by Powder Diffraction Methods, which has compiled data for the identification of approximately 5,000 crystalline materials by the Hanawalt Method. The Joint Committee is sponsored by the American Crystallographic Association, the British Institute of Physics, the National Association of Corrosion Engineers, and ASTM. The data have been collected from industry, literature, and laboratories and are available on plain 3- by 5-inch cards, 4- by 6-inch Keysort cards, and standard IBM cards. The Keysort cards have the Keysort coding around the border with holes punched but not notch coded. Instructions for coding are supplied with the Keysort cards.

Beside the great demand for this data by research laboratories, geological and research departments of universities, Government and industrial laboratories in the United States and Canada, this X-ray Diffraction Data File is being used by many laboratories in Great Britain, France, Italy, Germany, Belgium, Sweden, Switzerland, South America, Indonesia, Africa, Australia, Malaya, and Japan.

The editor of the card file is Dr. G. W. Brindley, of the Pennsylvania State University. Associate editors are: Dr. Benjamin Post, Polytechnic Institute of Brooklyn; Dr. Sigmund Weissman, Rutgers University; and Dr. L. G. Berry, Queen's University, Canada. Several research associateships at the National Bureau of Standards have been



THE FIRST nuclear reactor simulator for training and research in the United States is shown in operation at the atomic energy laboratory of Virginia Polytechnic Institute. J. W. Whittemore (*upper left*), dean of Engineering and Architecture, and Dr. T. M. Hahn, Jr. (*right*), head of Physics and Nuclear Engineering Physics, observe as a graduate engineer operates controls.



established by the Committee for the review, selection, and preparation of new patterns of standard materials as required.

Literature and schedule of prices of the X-ray Diffraction Data Card File will be furnished by writing the X-ray Department, American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa.

CU Offers Graduate Study Program for NSA

A program of studies leading to the degree, master of electrical engineering is currently being offered by the Catholic University of America (CU) for the National Security Agency (NSA), Washington, D.C. The program is offered for newly recruited engineers, who are full-time employees of the agency, in order to extend an opportunity for advanced study in the field of electrical engineering as well as for training in methods of investigation and research.

The courses, taught by regular staff members of the University faculty, are: electric circuit analysis, mathematics for engineers, microwave engineering, and solid-state engineering. These graduate courses normally are available to students who have received the bachelor's degree in physics or electrical engineering. Each student is enrolled initially with the University as a special student. The NSA sponsors the student with full pay and tuition for the first semester's courses. A student who successfully completes the four courses in the first semester with a scholastic grade of "B" or better, may continue his studies on-campus toward the master of electrical engineering degree. However, continuation studies are not a part of the NSA Graduate Studies Program and must be taken at the student's expense or under some other sponsorship program offered by NSA. Present plans call for repeating the program during both the first and second semesters.

NYU Will Offer Evening Electronics Courses

"Transistor Applications in Modern Electronics" is one of nine evening electronics courses to be offered during the spring semester at New York University's (NYU) Division of General Education, Dean P. A. McGhee has announced.

The courses—all of which meet for 15 weeks beginning in early February—are intended for adults interested in industrial electronics. Instructors will be professional engineers from the executive ranks of industry.

The transistor course, to be taught by Marvin Meth of the Radio Corporation of America (RCA) Laboratories in New York, N.Y., deals with the application of transistors to switching problems and amplification, and to portable AM and FM radio, television, computers, and other electronic devices.

The other electronics courses are: Elements of Electrical Theory, Mondays; Elements of Radio Tubes and Circuits, Mondays and Thursdays; Radio Tubes and Circuits II, Thursdays; Industrial Electronics, Wednesdays; Television Circuits, Fridays; Television Transmitter and UHF Circuits, Mondays; UHF and Microwave Communication Systems, Mondays; and Logical Design of Computers, Tuesdays.

A special certificate is awarded to students completing any four courses in the electronics curriculum, which is part of the Division of General Education's Program of Technical Studies. The program also offers basic courses in technical drawing, mathematics, physics, blueprint reading, and technical mathematics.

Interested persons may register by mail or in person from January 21 through February 8. Further information can be obtained from the Division of General Education, New York University, 1 Washington Square North, New York 3, N. Y.

Yale Traffic Bureau Will Increase Training Program

The Bureau of Highway Traffic at Yale University is increasing its training program to help meet the current high demand for engineers trained in street and highway operations. This demand has been produced by the current need for professional traffic engineering services in both urban and rural areas. It has been estimated that over 1,200 traffic operations engineers are needed throughout the country to help plan and design the new streets and highways to be provided by the National Highway Improvement Program and to relieve traffic congestion on existing streets through the application of regulations and controls.

The Bureau of Highway Traffic has been in operation since 1926. Its students hold responsible positions in highway traffic throughout the world. The traffic engineering course is at the graduate level and covers a full academic year with classes starting in September and terminating the following May. It is devoted entirely to highway traffic operations and is designed to equip men for responsible positions in this field of work upon graduation. The Bureau has graduated 396 men and 90.2 per cent of the graduates are actively engaged in traffic engineering work.

The academic year of study offered by the Bureau consists of two full semesters of classroom work, laboratory and individual research, required reading, field problems, and seminars. The courses include: traffic characteristics and measurements, traffic regulations and control devices, traffic facility planning and design, and highway administration and finance. Traffic experts from all over the country are invited to speak as guest lecturers at frequent intervals.

In 1957 the Bureau will offer a number of fellowships to citizens of the United States who are qualified for graduate work. All of the fellowships provide a living stipend of $1,400 disbursed at the rate of $175 per month for a period of eight months while a student is enrolled. The fellowships also provide the tuition fee of $600 which amounts to a total value of $2,000 for each fellowship. The fellowships are made available to the Bureau through grants from the Automative Safety Foundation, The Esso Safety Foundation, The Liberty Mutual Insurance Company, and The James S. Kemper Foundation. The International Road Educational Foundation provides financial aid to a limited number of foreign students.

In addition to the fellowships, the Bureau offers tuition scholarships to qualified municipal and state highway engineers who will receive salaries from their employers while undertaking the graduate work. This arrangement is considered by many employers to be a form of in-service personnel training.

Applications for admission and fellowships may be obtained by writing to F. W. Hurd, Director, Bureau of Highway Traffic, Yale University, Strathcona Hall, New Haven, Conn. The closing date for filing applications is March 1, 1957. Previous experience in traffic work is not essential to become a successful candidate for a fellowship or scholarship when high academic qualifications are indicated.

ASEE Will Present Seven Engineering Education Awards

Seven national awards in engineering education will be given by the American Society for Engineering Education (ASEE) at its 1957 Annual Meeting at Cornell University, June 17-21.

Competitions for all the awards are now open, and nomination blanks are ready, according to Prof. W. L. Collins, secretary of the Society.

The seven awards are:

1. The Lamme Award, given annually to an engineering educator for distinguished achievements contributing to the advancement of the profession. This is the Society's oldest award and its highest honor.

2. The George Westinghouse Award, an annual $1,000 prize for distinguished contributions to teaching engineering students. The Westinghouse Award is especially intended to encourage younger men who show superior teaching ability.

3. The Vincent Bendix Award, a gold medal given annually for top achievement in engineering research in colleges and uni-

versities. It is to recognize contributions through original research, research administration, leadership influencing the productive research of others, and the effective application of research results to the advancement of engineering education.

4. The Curtis W. McGraw Research Award to honor young staff members for contributions through engineering college research. This $1,000 prize, to be given for the first time next year, is to recognize outstanding early research achievements and to encourage the continuance of such activity in the future.

5. The James H. McGraw Award in Technical Institute Education is an annual prize of $500 presented for established achievement in technical institute education—teaching, administration, publications, and other forms of leadership.

6. The President's Awards to Young Engineering Teachers, given annually for papers written by young engineering teachers on a phase of engineering education. The contest seeks to encourage the participation of young teachers, 36 years or younger, in the problems of engineering education. Prizes of $200 and $100 are given for the two top-ranking papers.

7. The Engineering Drawing Award of a certificate for distinguished service by a member of the Society's Engineering Drawing Division. The qualifications include a record of successful teaching, improvement of the tools and conditions for teaching, scholarly contributions to engineering drawing, and service to the Division.

The Society's awards are given to winners selected, in each case, by special committees assigned to study the records of each nominee. Further information and blanks for nominations are available from Prof. W. L. Collins, secretary of the Society, at the University of Illinois, Urbana, Ill

Armstrong Memorial Grant Given to Columbia University

The first installment of a gift in memory of the late Major E. H. Armstrong (HM '53) has been made to Columbia University by the Armstrong Memorial Research Foundation, Inc.

G. E. Burghard, president of the Foundation, handed a check for $10,000 to Dr. Grayson Kirk, president, who accepted it on behalf of the University. The gift represents part of a $40,000 grant made to the University by the Armstrong Foundation, Inc., a nonprofit membership corporation.

The Foundation was established by Major Armstrong's close friends and associates to perpetuate the name and works of the late radio inventor. The money will go toward construction of a laboratory in electrical engineering at Columbia, determined by the Foundation as being the most logical memorial to Major Armstrong.

The expressed purposes of the Foundation include aiding in the continuation of basic research that was carried on by Armstrong, as professor of electrical engineering at Columbia and to contribute to the education and training of engineers and scientists capable of doing basic applied research in electronics and related fields.

Dr. Shockley Addresses U. S. Naval Postgraduate School

Dr. William Shockley, director of the Shockley Laboratory of the Beckman Instrument Company, presented an address on November 21 before 400 persons at the U. S. Naval Postgraduate School at Monterey, Calif. The address was jointly sponsored by the AIEE, the Sigma Xi Club, and the Institute of Radio Engineers of the school, and was open to the public.

Dr. Shockley spoke for two hours on theory and technical development of transistors. He and Doctors Bardeen and Brittain were selected to receive this year's Nobel Prize in Physics for development of the transistor (January 1957 *Electrical Engineering*, pp. 101-2).

A graduate of California Institute of Technology, Dr. Shockley received his doctorate at the Massachusetts Institute of Technology, where he later taught. He has long been known for his work in the general field of solid-state physics.

During World War II, he assisted in antisubmarine warfare research and was consultant to the Secretary of War as well as a director in the research weapons and evaluation groups.

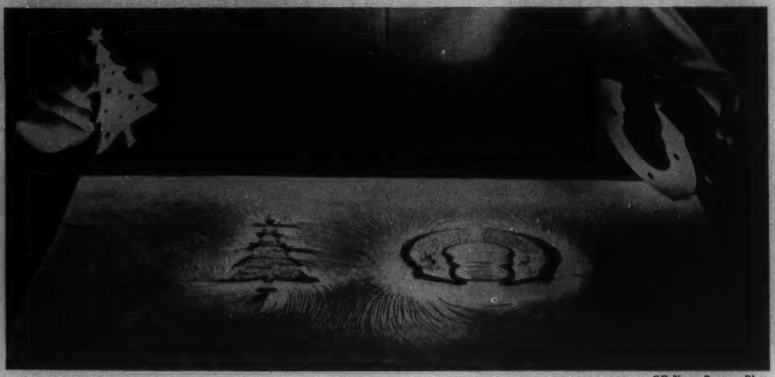
Cooper Union Receives $10,000 Scholarship Grant

Dr. D. B. Steinman, consulting engineer with offices in New York, N. Y., has made a grant, through the David B. Steinman Foundation, of $10,000 to The Cooper Union for the Advancement of Science and Art. The fund will be used for scholarship loan purposes for engineering students of the college, as well as for graduates who need financial assistance.

Engineering Scholarship Winners

TWO FRESHMEN AND A SOPHOMORE attend the University of Tennessee as winners of engineering scholarships offered by Fulton Sylphon Division of Robertshaw-Fulton Controls Company, Knoxville, Tenn. F. G. Cross (*left*), divisional general manager and company vice-president, presents winners (*left to right*) V. L. Ridenour, J. E. Trotter, and C. A. Clark with cash awards for $100, a part of the scholarships valued at $1,300 each. Winners, all majoring in engineering, are shown in uniforms of ROTC units at the University. Mr. Trotter, the sophomore, is the son of a Robertshaw-Fulton employee. The controls company sponsors the annual competition to encourage and assist deserving high school graduates in the study of engineering.

OF CURRENT INTEREST



GE News Bureau Photo

REVOLUTIONARY fine-particle iron magnet molded in the form of a Christmas tree demonstrates unique versatility. The flux patterns compare the unusual magnetic fields attainable with the new material to those of a conventional cast horseshoe magnet.

Invisible Iron "Dust" a Potential Superstrong Magnet

WORKING with invisible iron "dust," researchers have created a revolutionary and potentially superstrong magnet at the General Electric Company.

Dr. T. O. Paine (AM '54), of the company's Instrument Department at Lynn, Mass., told the American Association for the Advancement of Science (AAAS) that the unique properties of this magnet are achieved by precisely controlling the size and shape of individual iron particles so small that there are more than a *billion* billion in a pound.

Speaking at the annual Citation Dinner, sponsored by the Industrial Science Section of the AAAS, Dr. Paine said that, theoretically, the ultrafine particle iron magnet can be made 10 times stronger than the best available magnets. Already, experimental magnets have been made equal to the strongest commercial magnets, he added.

Citation Presentation

Highlight of the dinner was a citation, presented by Dr. A. T. Bonnell, section secretary, to E. E. Parker, instrument department general manager, calling the development "one of the major forward steps in industrial science in 1956." Dr. Bonnell is vice-president of Drexel Institute of Technology.

"The new magnet," Mr. Parker said, "will result in electric instruments that are smaller, lighter, more accurate and more rugged, making possible significant advances in instrumentation. It will help us make better photographic exposure meters, aircraft instruments and other products using permanent magnets.

"Although it will be quite some time before the new magnets are available commercially, the door is now open to new magnet applications as significant as those that followed General Electric's introduction of Alnico.

New Design Vistas

"This development opens whole new vistas to the design engineer because the iron particles can be embedded in plastics, metal, rubber, or glass. The magnets are easily machined, drilled, tapped, soldered, and molded precisely into any number of desired shapes.

"Ordinary iron is used in the form of submicroscopic elongated particles to make the new magnet. This leads to another far-reaching benefit: the saving of strategic metals like nickel and cobalt—heavily used in making most magnets. Elimination of cobalt makes possible the application of magnets in nuclear reactors, where magnets containing cobalt cannot be used because of high induced radioactivity.

"Several years of close co-operation between scientists at the instrument department and the company's Research Laboratory in Schenectady, N. Y., gave us the research depth to 'break through' a scientific frontier that has been a world-wide goal for many years."

Theoretical Speculation

In his speech to the AAAS, Dr. Paine, manager of the instrument department's measurements laboratory, said work on the development has been carried on by a small creative group in his organization. The research team started with only the speculation of theoretical physicists that ultrafine elongated iron particles might have a high resistance to demagnetization. But because iron particles tend to grow round, all efforts to produce these elongated shapes had failed.

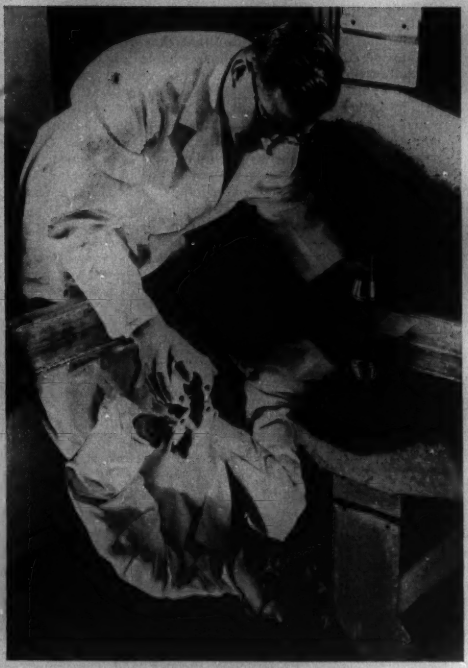
Dr. Paine and his group faced a seemingly insurmountable obstacle. How could they control the shape of iron particles finer than the smoke from a cigarette, smaller than the wavelength of light, invisible under a conventional microscope, so small that there are more than a billion billion in a pound?

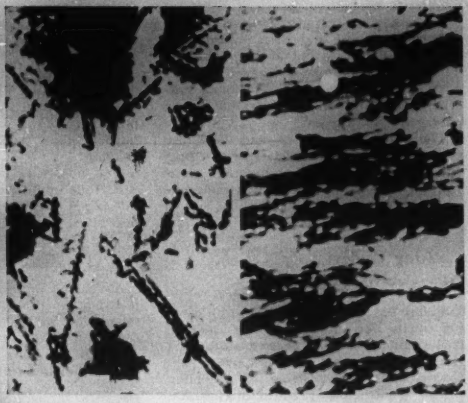
The "Break Through"

Experiment after experiment failed. Then finally the "break through" came. They produced a few particles with significant elongations. The most powerful electron microscopes—through which the iron "dust" can be seen—confirmed these results and subsequent experiments which brought full success.

"The magnetic and mechanical properties of this material can be controlled precisely," Dr. Paine said. "Not only can the qualities of available magnets be duplicated, but we can also achieve characteristics previously unattainable."

The citation presented to General Electric by the AAAS is awarded to companies responsible for practical industrial application of basic scientific discoveries. The Industrial Science Section, which makes the award, has a threefold purpose: first, to advance the knowledge and application of science in industry; second, to further the





GE News Bureau Photo

DR. T. O. PAINE (*left*), leader of a General Electric research team that developed a revolutionary permanent magnet, is collecting submicroscopic iron particles with a conventional magnet from this pool of liquid metal. This equipment produces more than a million billion particles per second which later are pressed to form a magnet potentially twice as powerful as any in existence today. Iron "dust," used to make a revolutionary new magnet, is shown (above) as it appears under the powerful electron microscope, magnified 100,000 times. Each of the ultra-fine, elongated iron particles is a separate magnet. The new material derives potential superstrength and unique versatility from the researchers' ability to "break up" the magnetic log jam (micrograph, *left*) and line up the minuscule iron particles (micrograph, *right*) to achieve optimum strength.

GE News Bureau Photo

interest and status of scientists engaged in research, education, or other work relating to the development, application, and use of scientific principles and knowledge to problems of industrial operations and management; and third, to promote public understanding and appreciation of the importance and promise of industrial science in human progress and welfare.

As is the case whenever there is a new development, the full impact can be measured only in retrospect. Meanwhile, it is certain that the work will continue toward the theoretical limit of magnetic energy.

61-Foot Diameter Antenna at Stanford Research Institute

TRANSMISSION and reception of radio signals are frequently and drastically influenced by "upper-atmosphere clutter" due to reflection from meteor and auroral ionization. As a result of such problems, Stanford Research Institute's (SRI) Special Techniques Group has embarked on a research program to gather information about the reflections of very-high frequency (VHF) and ultrahigh frequency (UHF) radio signals from meteoric and auroral ionization.

Initially, the program is being carried out in co-operation with Stanford University in the hills immediately to the west of the campus. The Rome Air Development Center, Air Research and Development Command, Griffis Air Force Base, N.Y., is sponsoring the effort.

The observations and conclusions will be utilized in part as a yardstick in the second segment of the program. The latter phase, which was initiated in the fall of 1956 and which will run well into 1957, will be carried out in conjunction with the Geophysical Institute, University of Alaska, at College, Alaska, near Fairbanks.

The Special Techniques Group intends to determine characteristics of radio-signal scattering and reflection by meteor trails in the frequency range from 100 to 400 mc; similarly, the reflection of radio waves by the ionization associated with the aurora borealis will be studied.

Various research and academic organizations have conducted studies of meteoric and auroral ionization in the frequency range below 100 mc. The result has been a much better understanding, at frequencies below 50 mc, of the frequency-time-amplitude relationship of the echoes. However, extrapolating the lower-frequency experiments and theory to the 100- to 400-mc frequency range has not previously been possible without the findings of experiments such as are promoted through this program.

To carry out the project, two large flexible radars have been designed and constructed. One consists of a 50,000-watt FM broadcasting transmitter operating at 100 mc which has been modified for pulse transmission. The second radar utilizes a large Eitel-McCullough, Incorporated, klystron amplifier. The transmitter generates power outputs up to 60,000 watts in the 200- to 400-mc range. The transmitters are mounted in large van-type shelters.

Pulse widths available on the two equipments can be varied from 50 microseconds to 1 second. Pulse repetition frequency is variable between 1,500 cps and 0.1 cps. Multiple pulsing also is possible with groups of four pulses available.

The receiving equipment has noise figures of 3, 3.5, and 4.5 db, respectively, at 100, 200, and 400 mc. The received bandwidths are variable between 3 kc and 16 kc. Phase coherent detection also is available to measure the sign and magnitude of Doppler shifts.

Parabolic antennas, 61 feet in diameter, designed by SRI will be used with the radars (see cover picture). The antennas are movable in both elevation and azimuth. The 100-mc antenna has a gain of 24 db and a beam width of 12 degrees. The 200- to 400-mc antenna has a gain of 30 and 36 db, respectively. At 200 mc the beam width is 6 degrees, and at 400 mc it is 3 degrees.

The antennas each are quite light, the dish alone weighing only 2,500 pounds. They are constructed of aluminum to withstand 100-miles-per-hour winds, and are

on an elevation-azimuth mount. The antennas are of a "bolt-together" variety and can be assembled and disassembled with minimum difficulty, and allow portability. The radar transmitting and receiving equipment is housed in 10- by 40-foot van-type shelters forming semiportable power packages.

The relative sensitivity and flexibility of these radars make them especially suitable for other types of propagation investigation such as moon reflections and forward scatter.

Cooking Under New Catalytic Lid

Science has found a way to burn up cooking smells like those of boiling cabbage, frying onions, or even charred steaks and chops before they get out of the pot or pan. Grease, accustomed to flying like a homing pigeon to kitchen walls and ceilings, is destroyed in the same operation.

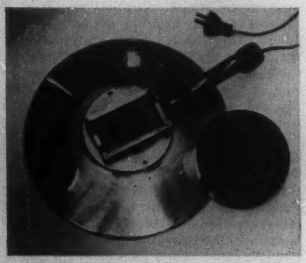
A new electric appliance that converts the objectionable smells, smoke, and grease of top-of-the-range cooking into a clean, odorless effluent, has been developed by Oxy-Catalyst, Inc., Wayne, Pa. It eliminates the need to open doors or windows or to use a ventilating fan, during cooking time.

The device, called the first really new electric appliance since air conditioning, consists of a unique electrically heated wire catalyst fitted into the center of a 12-inch diameter aluminum cover.

The catalyst burns without flame the objectionable by-products of cooking as they rise through the opening in the center of the appliance.

Oxy-Catalyst has licensed Kamkap, Inc., a leading producer of housewares, to manufacture and market the catalytic lid under its own name. Kamkap introduced the new appliance at the National Housewares Show in January.

The catalytic element, called an Oxycoil, which makes fumeless cooking possible, was developed by Oxy-Catalyst last year for electric range oven applications. The Oxycoil consists basically of a number of turns of catalyst-coated resistance wire wrapped around two porcelain end posts. This assembly is mounted in a stainless steel frame which is temperature and shock resistant.



REMOVAL OF TOP of the catalytic lid exposes the catalytic element that is the secret of odorless, smokeless, greaseless cooking. Fumes from the food flow up through an opening in the aluminum cover and on contact with the catalyst are burned without flame into a harmless odorless effient.

The catalyst, a chemical compound containing platinum, burns combustibles in a stream of air at relatively low temperatures —temperatures too low to support ordinary flame combustion. Oxy-Catalyst has already put similar catalysts to work in industrial pollution control systems and in special mufflers that purify automotive engine exhausts.

The housewife uses the new appliance just as she would a conventional pot or pan lid—except that she first plugs it into the nearest electric outlet. The resistance wire in the Oxycoil brings the catalyst to its operating temperature in about thirty seconds.

As cooking proceeds, the fumes from the food flow up through the open grid of catalyst wire in the center of the lid. On contact with the coated wires all organic combustibles—odors, smoke, grease, and other impurities—are catalytically burned.

The catalyst does not mask smells and smoke. It literally destroys these contaminants at their source. The end products vented to the kitchen are invisible, harmless, greaseless, odorless vapors.

Elimination of the grease vapors that continually build up on kitchen surfaces promises an end to a major housecleaning problem.

The 12-inch diameter of the catalytic lid permits its use with any round pot or pan of that size or smaller.

The catalytic wire is self-cleaning. It has been tested successfully for the equivalent of 10,000 cooking hours. The catalytic element can be easily snapped out before washing the rest of the unit.

The new appliance is rated at 175 watts, 110 volts a-c or d-c.

AEC Announces Various Developments

Revised Declassification Guide. A tripartite agreement to declassify additional information essential to the development of a civilian nuclear industry has been made between the United States, Great Britain, and Canada. The information available in the new Guide relates to all phases of nuclear power from ore recovery and fabrication of fuel elements to the design and operation of plants for the chemical recycling of spent fuel elements from civilian reactors.

Gas-Cooled Reactor Experiment. The design, fabrication, and operation of a gas-cooled reactor experiment intended to develop engineering data and experience for the construction of military package power reactors and small civilian central station power plants will be started at the National Reactor Testing Station in Idaho, in conjunction with the Aerojet-General Corporation of Azusa, Calif.

Additional Radioactive Sources under General Licensing. The Atomic Energy Commission has amended its by-product material (radioisotope) regulation to permit the possession and use under general license of additional types of low-level radioactive sealed sources. This has been done to permit them to be sold without requiring the user to obtain a specific license. The radiation hazard associated with the various items was studied carefully by an advisory committee in addition to the AEC which determined that the items did not constitute an unreasonable risk to the health and safety of the general public. Sealed sources placed under general license are: (1) spark gap tubes and electronic tubes containing not more than 5 microcuries (μc) per tube of krypton-85 gas; (2) light meters incorporating as a sealed source not more than 200 μc of strontium-90, for use in photography; and (3) ion generating tubes containing not more than 500 μc per tube of polonium-210, for use in air conditioning and other equipment.

Guaranteed Prices for Special Nuclear Materials. The AEC has established guaranteed fair prices to be paid for plutonium and uranium-233 (U-233) produced in atomic reactors operated under license in the United States and delivered to the AEC for the one-year period from July 1, 1962, through June 30, 1963. The prices are: $12 per gram for plutonium metal, and $15 per gram for U-233, based on the estimated fuel value of the materials and are identical with those to be paid for these products of reactors abroad fueled with material supplied by the United States.

Unsolved Problems and Forgotten Facts

All well-informed persons realize that unknown truths are probably as numerous as the known ones. But nobody has yet attempted to explore in detail what remains to be done in each and every area of knowledge. That is what we propose to do.

Consequently, if readers of *Electrical Engineering* are aware of any significant problem in their own field which has up until now remained unsolved, or any important fact which has been somehow neglected, they are invited to take part in our survey, entitled "Nobody Knows: A Survey of Unsolved Problems and Forgotten Facts," which will be published in 1958 by the Philosophical Library in New York, N.Y.

This survey may occupy several volumes containing a great variety of material arranged by topics and provided with cross references. It will serve as a reference work for scholars and students. Typical entries will be: nobody knows the causes of cancer, nobody has explained the physiology of sleep, nobody has succeeded in proving that Joan of Arc was actually burned to death, etc.

All papers should be limited to a mere exposition of the problem in question and should not exceed 1,500 words. Each author is asked to write in such fashion as to be understood by the general reader. Papers are expected to be properly typewritten, dated, and signed; and, if the writer so wishes, the name of the institution with which he is connected may appear under his signature. A few bibliographical references are desirable.

A Board of Editors, composed of recognized authorities in each field, will read every article submitted, and each author will receive full credit for every published piece.

Papers should be sent to Dr. R. B. Winn, 224 Cummings Ave., Elberon, N.J.

Heat Pump Weathermaker for Residential and Commercial Use

Year-round residential and commercial air conditioning has been packaged into a new heat pump designed to cut both first cost and operating cost for such equipment and to reduce space needed indoors to a minimum.

At the same time, Carrier Corporation also introduced a new series of assemblies for "applied" or field-engineered heat pump systems for larger buildings while predicting substantial future sales growth for both types of heat pumps.

A heat pump is an air conditioner which uses refrigeration to provide winter heating as well as summer cooling. A refrigerating system operates on the principle of taking heat from one medium and releasing it at a higher temperature to another. In a heat pump it can be "turned around" to extract heat from outside and discharge it into a building in winter as well as to draw heat from the building and discharge it outside in summer.

The Heat Pump Weathermaker which employs outdoor air as a source of heat is divided into two units, with an indoor unit little larger than a room air conditioner. It requires virtually no space inside a home or commercial building, can be installed in an attic, basement, or top of closet, yet it can do the entire job of heating and cooling.

It was predicted that about 10,000 packaged air-to-air heat pumps would be installed by the industry during 1957, and that the annual figure would increase to 30,000 by 1961. At the same time, emphasis was given to the fact that the heat pump is fundamentally another way to provide year-round air conditioning and that its growth possibilities can only be considered as part of the over-all rise in demand for complete air conditioning.

The new "Climate-Balance" principle was described as such that the heat pump could be considered a desirable way to do the heating job wherever the refrigeration required for cooling can also supply a large portion of heating needs and where fuel-electric costs are comparable.

It was stated that the Heat Pump Weathermaker was the first unit designed specifically to achieve maximum economy over the year-round range of operating temperatures.

The unit has a two-piece design which permits complete flexibility of installation and a consequent reduction in installation cost in many cases. Because the portion of the heat pump requiring outside air is located exterior to the structure, it is no longer necessary to install expensive duct-work inside the building to bring in the air from which heat is taken. Thus, sheet metal costs and any noise incident to moving large quantities of air can be reduced greatly.

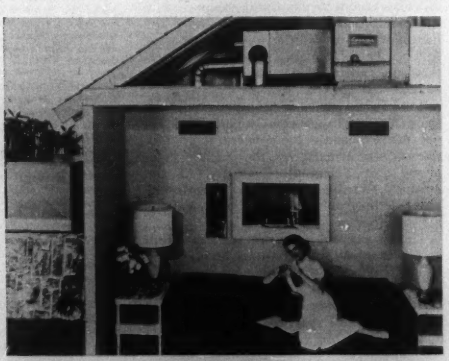
The indoor unit takes no usable floor area—an important point in new construction where area is considered to cost anywhere from $12 a square foot up. In fact, this new heat pump takes less space than a conventional furnace and cooling unit combination. It may use either air or water as a source of heat.

Characteristic of heat pumps is the fact that every unit of electrical energy used will produce a considerably greater amount of heat energy, inasmuch as its operation basically is that of employing electro-mechanical energy to take heat from air or water rather than simply converting electrical energy to heat.

Thus, an air source heat pump may deliver nearly three units of heat energy for every unit of electrical energy. With water this coefficient of performance may increase to from five to seven units of heat per unit of electricity.

The biggest market for water-source heat pumps will be in areas where there is a cheap supply of water readily available and easy to dispose of and where the water is of a type which will not cause scale or corrosion. Maintenance problems resulting from scale or corrosion which occur with many types of water will probably lead to predominant use of air-source heat pumps in smaller commercial buildings.

One interesting approach called a "run-around" system can be used with many block-type buildings, it was explained. In such structures, interior spaces may need cooling in winter as well as summer since they are not exposed to the cold weather outside. The heat extracted by the refrigeration system from these spaces may then be pumped to exterior offices where it would provide heating. The same approach can be used in many factory-office combinations. Heat generated by production machinery is removed by the heat pump, cooling factory space, then sent to heat offices.



HEAT PUMP Weathermaker is latest advance in all-electric heating and cooling. Small indoor unit, shown in attic, is little larger than a room air conditioner yet can do entire job of year-round air conditioning for a home or small commercial building.

Future Meetings of Other Societies

Pennsylvania Electric Association, Winter Meeting:

Transmission and Distribution Committee, January 31-February 1, Penn Harris Hotel, Harrisburg, Pa.

Hydraulic Power Committee, January 31-February 1, Brunswick Hotel, Lancaster, Pa.

Electric Equipment Committee, February 7-8, Benjamin Franklin Hotel, Philadelphia, Pa.

Communications Committee, February 11-12, Hotel Americus, Allentown, Pa.

System Planning Committee, Systems Operation Committee, Joint Meeting, February 14-15, Benjamin Franklin Hotel, Philadelphia, Pa.

9th Annual Industrial Engineering Institute, February 1-2, simultaneous sessions at University of California at Berkeley and Los Angeles, Calif.

American Society of Heating and Air-Conditioning Engineers, 66th Annual Meeting and 2nd Exposition, February 1-5, Dallas, Tex.

26th Annual Midwinter Conference, Public Utility Buyers' Group, February 3-5. The Brown Hotel, Louisville, Ky.

ASTM, National Meeting, February 4-8, Benjamin Franklin Hotel, Philadelphia, Pa.

National Auto Accessories Exposition, February 4-8. New York Coliseum, New York, N. Y.

Western Winter Radio-Television and Appliance Market (Div. Western Home Goods Market), February 4-8. Western Merchandise Mart, San Francisco, Calif.

The Society of the Plastic Industry, Inc., Reinforced Plastics Division, 12th Annual Technical and Management Conference, February 5-7, Edgewater Beach Hotel, Chicago, Ill.

National Science Foundation, Colloquia Series, "Industrial Laboratory Research," February 6, National Science Foundation, Washington, D. C.

Society of Industrial and Applied Mathematics, Symposium on Operations Research, February 7, Princeton, N. J.

ISA, Aircraft Instrumentation Symposium, February 7, Garden City Hotel, Garden City, L.I., N. Y.

IRE, Operations Research Symposium, February 7, University of Pennsylvania Museum, Philadelphia, Pa.

Audio Engineering Society, 1957 West Coast Convention, February 7-8, Ambassador Hotel, Los Angeles, Calif.

Nucleonics in Industry, Special Conference, AMA, February 7-8. Hotel Statler, New York, N. Y.

Symposium on Recording Heart Sounds, February 14, University of Buffalo Medical School—IRE, Buffalo, N. Y.

NSPE, Spring Meeting, February 15-16, Hotel Francis Marion, Charleston, S. C.

Cleveland Electronics Conference, February 15-16, Masonic Auditorium, Cleveland, Ohio.

National Photographic Show, February 16-24, New York Coliseum, New York, N. Y.

National Electric Sign Association, Annual Convention and Exhibit, February 17-20, Sheraton Park Hotel, Washington, D. C.

ASCE, Semiannual Convention, February 18-22, Jackson, Miss.

13th Annual National Adequate Wiring Conference, February 21-22, Sherman Hotel, Chicago, Ill.

AIME, Annual Meeting, February 24, Hotel Roosevelt and Hotel Jung, New Orleans, La.

Electronics in Action, Special AMA Finance Division Conference, February 25-27, Hotel Statler, New York, N. Y.

ASHAE, International Heating and Air-Conditioning Annual Meeting and Exposition, February 25-28, International Amphitheatre, Chicago, Ill.

Military—Industry Guided Missile Electronic Test Instrument Symposium, February 26-28, Redstone Arsenal, Huntsville, Ala.

13th International Heating and Air-Conditioning Exposition, February 25-March 1, Chicago, Ill.

3rd Radio-Interference Reduction Conference, February 26-27, Armour Research Foundation, Chicago, Ill.

The initial unit will be a 5-horsepower model, which is expected to be the most popular size for residences and small commercial buildings. In addition Carrier will begin production on a larger size and will eventually manufacture the unit in smaller models as well. Heat pump systems will be available in sizes ranging from 10 to 125 horsepower.

Purdue Professor Named Chemical Engineers President

Dr. J. H. Rushton, professor of chemical engineering, Purdue University, has been elected 1957 President of the American Institute of Chemical Engineers (AIChE), it was announced at the 49th Annual Meeting of the AIChE in the Statler Hotel, Boston, Mass.

At the same time it was announced that G. E. Holbrook, the assistant general manager of the Organic Chemical Department, E. I du Pont de Nemours & Co. (Inc.), Wilmington, Del., has been elected vice-president; Dr. George G. Brown, dean of the College of Engineering, University of Michigan, re-elected treasurer, and F. J. Van Antwerpen of Nutley, N. J., re-elected secretary.

Professor Rushton has had a distinguished career in education and as a consultant, and has been active in AIChE affairs for many years. Prior to assuming his present Purdue post, he was professor and head of the chemical engineering department at the University of Virginia for a decade and held a similar position with the Illinois Institute of Technology. He has been consultant to the Department of Defense, the Atomic Energy Commission, and to firms in the petroleum and food fields. He served as vice-president of AIChE in 1956 and has held similar posts and has served on engineering and educational bodies. He was presented the William H. Walker Award in 1952.

Dr. Holbrook has been on the Du Pont engineering staff since 1933 and has served as head of the New Products Division, as assistant director of the Jackson Laboratory, general superintendent of the Development Chambers Works, and assistant director of the Technical Division, Organic Chemical Department. He was director of the Technical Division, National Production Authority, in 1952. He has also been active in AIChE, and won the Professional Progress Award in 1953.

Submarine Telephone Cable Stretches Throughout Alaska

The U. S. Army Signal Corps and the Bell Telephone System opened to public service today a new and important communications link between the United States and the growing Territory of Alaska. The link consists of an underwater telephone cable system stretching some 1,250 miles from Port Angeles, Wash., to Skagway, Alaska.

Hatfield Chilson, Assistant Secretary of Interior and B. F. Heintzleman, Governor of Alaska, made the first call over the new system. Mr. Chilson spoke from Washington and Mr. Heintzleman from Juneau.

The inaugural call was made over a 4,600 mile telephone network that linked Washington to Juneau and included Seattle, Ketchikan, Anchorage, and Fairbanks. At each location, Government, military, and industry officials participated in the ceremonies.

In addition to Mr. Chilson, the Washington group included Secretary of the Army Wilber Brucker; George McConnaughey, Chairman of the Federal Communications Commission; E. L. Bartlett, Congressional Delegate for Alaska; Major General W. P. Corderman, Acting Chief Signal Officer; Admiral J. N. Wenger of the Joint Chiefs of Staff; and W. G. Thompson, Assistant Vice-President of American Telephone and Telegraph Company (AT&T).

The cable system represents two major projects—one provided by the Long Lines Department of AT&T; the other by the Alaska Communication System (ACS), which is operated by the Signal Corps.

The AT&T cable system extends from Port Angeles to Ketchikan, Alaska, a distance of about 900 miles. Twin cables, containing built-in amplifiers, lie in the ocean depths off the coast between the two points. These cables were placed by the cableship *Albert J. Myer* between early June and late August 1956. They are similar in design and construction to the transatlantic telephone cable system—the first such system to cross an ocean—which went into service in September (story in December 1956 issue *Electrical Engineering*, pp. 1134-36).

The ACS cable, which covers the 400 miles betwen Ketchikan and Skagway, is a single submarine cable stretching along the inland waterway on the southern coast of Alaska. This cable utilizes amplifying stations that are located on islands or points of land that dot that area.

From Port Angeles, the southern terminal, the cable circuits are connected to the U. S. network at Seattle by a radio relay link recently constructed by the Pacific Telephone and Telegraph Company. At the northern end, beyond Skagway, the circuits are fed into the Alaska communications network, operated by ACS.

The system took over two years to build. It can carry 36 conversations at one time and will be used to supplement the radio-telephone and land line facilities that have been operating between the United States and Alaska since 1937.

The new cable system will more than double the capacity of the radio and land line circuits and will perform with the clarity and reliability of the best States-side telephone line. It will add to the flexibility, security, and reliability of the United States–Alaska facilities.

U. S. Army Photograph

VIEW OF CABLE landing operation at Skagway beach. Cableship *Albert J. Myer* in background. Large section of drum and balloon supported section cable submerged.

NEW BOOKS

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

CHROMIUM. Volume 2. Metallurgy of Chromium and Its Alloys. By M. J. Udy. A.C.S. Monograph No. 132. Reinhold Publishing Corp., 430 Park Ave., New York 22, N.Y., 1956, 402 pages, 6 by 9¼ inches, bound. $11. This volume deals with American and European methods of recovery, electrowinning, electroplating, and various methods of deposition, giving a considerable amount of detailed, practical operational data. It also deals fully with the production of ductile chromium, chromium in refractories, and the properties and uses of the metal and its alloys with iron, steel, cast-iron, cobalt, nickel, aluminum, copper, and titanium. Phase diagrams of a number of metals are included, and extensive reference lists accompany each chapter.

DEVELOPMENT OF POWER CABLES. By P. V. Hunter and J. T. Hazell. George Newnes, Ltd., London, England, 1956. 150 pages, 5½ by 8¾ inches, bound. 25s. The contributions of engineers of all countries to progress in cable materials and design are recorded in this history. The account ranges from early experiments in the transmission of current to such modern developments as gas pressure, oil-filled, and aluminum cables.

ELECTRICAL TESTING AND TROUBLESHOOTING. By P. T. Green. The Industrial Press, 93 Worth St., New York 13, N.Y., 1956, 191 pages, 6 by 9¼ inches, bound. $4. A practical manual of procedures for locating and correcting faults in controllers, test equipment, transformers, motors, power cables, etc. No mathematical knowledge is required for the use of the procedures described.

ELECTRONIC ANALOG COMPUTERS. (D-C Analog Computers) By G. A. Korn and T. M. Korn. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., second editon, 1956. 452 pages, 6 by 9¼ inches, bound. $7.50. This book describes a standard procedure for setting up a computer to solve a given set of differential equations, and presents setups for such practical problems as automobile suspension systems and industrial process control. It also covers the design of computing elements, amplifier circuits, and auxiliary components. Developments in analog multiplication and function generation are discussed, and the design and construction of complete computer installations are given for various applications in industry and science. No mathematics beyond differential equations is required of the reader.

ENGINEERING INSPECTION, MEASUREMENT AND TESTING. By H. C. Town and R. Colebourne. Philosophical Library, Inc., 15 E. 40th St., New York 16, N.Y., 1956. 191 pages, 5⅞ by 9 inches, bound. $8.75.

The greater part of this book is devoted to descriptions of various devices and to brief indications of their applications. The devices covered include comparators, linear measuring machines, multidimension inspection machines, autocollimators, etc. Also dealt with are the functions of the inspection department, principles of precision measurement, measurement during machining, inspection methods and calculations, screw thread measurement, and the measurement of surface finish.

FREQUENCY MODULATION ENGINEERING. By C. E. Tibbs and G. G. Johnstone. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., second edition, 1956. 435 pages, 5½ by 8¼ inches, bound. $9.50. A revised and enlarged edition of a concise survey of the whole field, presented in a style suited to the practicing engineer. The first part of the book deals with frequency modulation of carrier waves, interference suppression, propagation, aerials, transmitters, and measurements. The remainder is devoted to descriptions of the technique and circuits used for frequency modulation and reception. Circuits of commercial equipment are described when possible, and working designs with characteristics curves are included in the material on components.

HANDBOOK OF INDUSTRIAL ELECTRONIC CONTROL CIRCUITS. By J. Markus and V. Zeluff. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., first edition 1956. 352 pages, 8½ by 11¼ inches, bound. $8.75. A compilation of about 300 circuits, selected from issues of *Electronics* magazine since 1948. The circuits included are grouped by function as follows: amplifiers, capacitance control, cathode-ray control, counters, direct current amplifiers, measuring circuits, metal detectors, motor controls, multivibrators, oscillators, photoelectric circuits, power supply circuits, radiation circuits, remote control, sorting, temperature control, timing, transistor circuits, ultrasonic control, and welding control. In describing each circuit, information is given on its performance, components, and applications.

HANDBOOK OF MATERIAL TRADE NAMES. Supplement 1. By O. T. Zimmerman and I. Lavine. Industrial Research Service Inc., Dover, N.H., 1956. 383 pages, 7⅝ by 10⅝ inches, bound. $12.50 This supplement brings up to date a standard source of information on the nature and uses of trade name products. It is comprised, like the main volume, of an alphabetical list of products with descriptions, a classified section in which the trade names are grouped by major uses or composition, and a directory section giving manufacturers and their products. The supplement also contains a list of products withdrawn from the market since their inclusion in the 1953 edition.

HANDBOOK OF SEMICONDUCTOR ELECTRONICS. Edited by L. P. Hunter. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1956. Various paging, 6 by 9¼ inches, bound. $12. A reference manual for engineers concerned with the design and applications of semiconductor devices. Parts I and II deal with the basic physics and operating principles of diodes, photocells, and transistors, and with the processes used in their fabrication. Part III, which goes into greater detail than the other parts, covers the design of circuits: low-frequency amplifiers, high-frequency and video amplifiers, directly coupled amplifiers, transistor oscillators, transistor switching circuits, and circuits using special devices. Reference material on graphical analysis of nonlinear circuits, matrix methods of circuit analysis, and methods of measurement is provided in the fourth and last part of the book. A 68-page bibliography is appended.

HANDBUCH DER SONDERSTAHLKUNDE. By Eduard Houdremont. Springer-Verlag, Berlin, Germany, third edition, 1956. 1,538 pages, 6⅝ by 10 inches, bound. 2 volumes, DM 220. This 1,538-page reference work on alloy steels, brings together the relevant information contained in hundreds of articles, papers and reports. Following an opening chapter on the properties and characteristics of pure iron, Vol. I continues with extensive sections on carbon steels, including full coverage of their heat treatment, and on manganese, nickel, and chromium steels. Vol. II deals with tungsten, molybdenum, vanadium cobalts, and silicon as alloying elements, and with the effect on steel of aluminum, copper, titanium, phosphorus, sulphur, various gases, and some of the rarer elements. In each major section, the author considers general characteristics, tool steel alloys, structural steel alloys and the influence of the particular element on the physical and chemical properties of the steel, and on its manufacture and working. Metallurgical aspects are stressed throughout, with full illustration by means of constitution diagrams, microphotographs, and hundreds of graphs. In addition to the graphs, data tables present in concise form the information contained in the footnote references for which an author index is supplied.

INFORMATION THEORY AND ITS ENGINEERING APPLICATIONS. By D. A. Bell. Pitman Publishing Corp., 2 W. 45th St., New York 19, N.Y., second edition, 1956. 174 pages, 5½ by 8¾ inches, bound. $5. This is a concise summary of the substance of recent development, using only the mathematics ordinarily familiar to the electrical engineering or physics graduate. Chapters deal with the binary digit measure, entropy and information, signalling speed, signal-to-noise ratio, and coding. Applications such as pulse-modulated telephony, radar storage-systems, and color television are also discussed. A new chapter on decoding has been added to this edition.

AN INTRODUCTION TO MATRIX TENSOR METHODS IN THEORETICAL AND APPLIED MECHANICS. By S. F. Borg. J. W. Edwards, Publisher, Inc., Ann Arbor, Mich., 1956. 202 pages, 8½ by 11¼ inches, bound. $4.75. This text for senior and graduate engineering students deals briefly, in the first chapter, with matrix algebra, vector analysis, and complex variable theory as a preliminary to more extended treatments, in later chapters, of the following: tensors of zero, first and second order; the theory of elasticity and its application to the bending and torsion problems; the theory of plates and shells; equations of viscous flow; boundary layer theory; the theory of plasticity; curvilinear co-ordinates; and tensor analysis as related to dimensional analysis.

DIE MASSSYSTEME IN PHYSIK UND TECHNIK. By G. Oberdorfer. Springer-Verlag, Vienna, Austria, 1956. 140 pages, 6 by 9 inches, paper. $3.80. A critical study of the underlying principles with regard to the establishment of acceptable systems of units in physics and engineering. Existing systems are compared with special attention to the fields of mechanics, electricity, and thermodynamics. The concept of dimension is elaborated, and a catalog of the most important magnitudes, their dimensions and units, is included.

THE METROPOLITAN TRANSPORTATION PROBLEM. By Wilfred Owen. The Brookings Institution, 722 Jackson Pl., N.W., Washington 6, D.C., 1956. 301 pages, 6 by 9⅜ inches, bound. $4.50. This is a broad and critical survey covering various aspects of the subject as trends in population and economic activity; the failure of urban planning to take into account the increased use of private vehicles; the decline of mass transportation; current attempts to remedy the situation by expressways, terminals, and off-street parking; methods of financing and organising transportation systems; and city redevelopment. The author sees the solution to the problem in a program combining metropolitan redevelopment and the co-ordinated utilization of all methods of transportation.

MODERN MATHEMATICS FOR THE ENGINEER. Edited by E. F. Beckenbach. McGraw-Hill Book Company, Inc., 330 W. 42nd St., New York 36, N.Y., 1956. 514 pages, 6 by 9¼ inches, bound. $7.50. This book is based on a lecture series instituted at the University of California to acquaint engineers with recent advances in mathematics. Part I is devoted to physical problems expressed in terms of ordinary differential equations, integral equations, and partial differential equations. It contains chapters covering such subjects as equilibrium analysis, exterior ballistics, and boundary value problems. Part II deals with the theory of prediction, the theory of games, operations research, dynamic programming, and Monte Carlo methods. The last part covers engineering applications of matrices, functional transformations for engineering design, relaxation methods, and other computational considerations.

NUCLEAR ENERGY IN INDUSTRY. By J. G. Crowther. Pitman Publishing Corp., 2 W. 45th St., New York 19, N.Y., 1956. 168 pages, 5½ by 8¾ inches, bound. $3.95. The purpose of this book is to familiarize industrialists with the new materials, new instruments, and new techniques of the nuclear energy industry so that they can adopt those which may improve their own processes. In seven concise chapters, the author discusses the probable impact of the new source of power on world industry, the developments in nuclear science culminating in nuclear power stations, industrial uses of radioisotopes, prospecting for uranium, recovering uranium, and the preparation and treatment of nuclear fuels.

PETROGRAPHIC MODAL ANALYSIS. By Felix Chayes. John Wiley & Sons, Inc., 440 Fourth Ave., New York 16, N.Y., 1956. 113 pages, 5⅞ by 9¼ inches, bound. $5.50. Modal analysis, as a procedure which yields a statement of the relative amounts of minerals in rocks, though over 25 years old, has since 1945 been subjected to statistical reorientation studies. These studies, if the trend continues, may lead to acceptance of the method as the simplest, quickest, and cheapest analytical procedure available to the petrologist. This book describes the geometrical basis of the method, reviews the techniques and instruments used, and discusses forms and types of errors and ways to reduce them. The method has been treated so that geologists unfamiliar with statistics can follow the general outline of the discussion and make use of major conclusions.

PLUIE, EVAPORATION FILTRATION ET ECOULEMENT. (Société Hydrotechnique de France, Troisiemes Journées de L'Hydraulique, Alger, 1954). La Houille Blanche, Grenoble, France, 1955. 316 pages, 6⅝ by 11½ inches, paper. Francs 4,000. A group of 40 papers covering a wide range of topics in the field of hydrology: relations between various measurements, of precipitation, evaporation, run-off, etc.; relation between surface flow and substerranean flow; statistisal hydrology; soil permeability; reservoir silting; application of electric analogy to hydraulic flow. These are some of the more important subjects. Many papers relate to specific problems in defined areas. Each paper has an English abstract.

SYMPOSIUM ON HIGH-PURITY WATER CORROSION. (Special Technical Publication No. 179). The American Society for Testing Materials, 1916 Race St., Philadelphia 3, Pa., 1956. 56 pages, 5⅞ by 9 inches, paper. $1.75. Three of the five papers included are concerned with the corrosion problem in connection with high-temperature, high-purity water: the influence of water composition, the effect of material composition, and the corrosion of carbon and low alloy steels. The other two papers deal with the preparation and maintenance of high-purity water and the use of water in atomic reactors.

SYMPOSIUM ON TAP SORTS, INTERMITTENTS, AND FLICKER NOISE IN ELECTRON TUBES. (Los Angeles, Calif., August 1956). Sponsored by Joint Electron Tube Engineering Council and Aircraft Industries Association. Published by Radio-Electronics Television Manufacturers Association, 11 W. 42nd St., New York 36, N.Y. 44 pages, 8½ by 11 inches, spiral binding. $3. Two of the seven papers in this report describe the work of committees of the sponsoring organizations on problems of tap shorts and intermittents. The remaining papers deal with the following subjects: logical computer design to minimize tube noise effects, sampling for intermittent defects, influence of mechanical factors on instruments for testing tubes and shorts, shorts detectors, and Signal Corps electron tube mechanical reliability evaluation.

DIE TRANSFORMATOREN. By Rudolf Küchler. Springer-Verlag, Berlin, Germany. 1956. 321 pages, 6¼ by 9¼ inches, bound. DM 33. Beginning with description and analysis of basic types of transformers, the author continues with discussion of leakage flux and voltage, eddy current losses, short-circuit and voltage stresses, capacitance, step-wise regulation, cooling methods, design, and reduction of transformer noise. Special attention is paid to transformers for high-voltage networks and to transportable transformers.

VDI BERICHTE. Band 13. Energieerzeugung. Band 15. Luftverunreinigung. Band 16. Kraftfahrzeugtechnik. VDI-Verlag, Düsseldorf, Germany, 1956. 72 pages, 72 pages, 84 pages, 8¼ by 11⅝ inches, paper. DM 11.40, DM 13.80, DM 13.20. Continuing the series of reports on special meetings of the Verein Deutcher Ingenieure (VDI), these three publications deal with the following topics: Vol. 13. Eight papers on modern power production in public utilities and industry, covering efficiency, industrial turbines, large turbogenerrators, district heating, and new installations; Vol. 15. Nine papers on air pollution in connection with the cement industry, iron and steel industry, steam power plants, chemical industry, street traffic, and effect on vegetation; Vol. 16. Nine papers on automotive engineering; lightweight construction, brake-testing, steering forces, speed evaluation, multi-axle vehicles, etc.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

AUTOMATIC FLIGHT. The Radio Technical Commission for Aeronautics (RTCA) has released a report on its studies of the application of automatic flight techniques in the take-off, cruise, approach, landing, and taxiing phases of aeronautical operations. The report, prepared by RTCA Special Committee 18, describes six categories of automatic flight and defines fundamental terms to establish a basis for the formulation of automatic flight equipment nomenclature. A detailed analysis is made of the final approach problem. Criteria for the adjustment of ILS localizer facilities are recommended together with procedures whereby compliance with these criteria may be ascertained. Standards for localizer receiver output and

autopilot coupler output characteristics are also recommended. Copies of the report (Paper *151-56/DO-74*) may be obtained from the RTCA Secretariat, Room 2036, Building T-5, 16th & Constitution Ave., N.W., Washington 25, D.C., at a cost of $1.50 per copy.

DEVELOPMENT OF NONDESTRUCTIVE TESTS FOR STRUCTURAL ADHESIVE BONDS. A device called the STUB-meter which enables nondestructive evaluation of structural adhesive bonds by ultrasonic technique is under development for the Air Force. Data on its principles, construction and operation are summarized in a report just released for industry use through the Office of Technical Services (OTS), U. S. Department of Commerce. STUB-meter technique relies on the vibration behavior of a ferroelectric transducer, which indicates structural properties of adhesive bond specimens coupled to it. A plausibility argument for the little-understood relationship between bond strength and transducer behavior is presented in the report. Progress of development of a portable, laboratory STUB-meter is described in sections of the volume covering system analysis, electronics, transducers, measurements, and a projected exterior evaluation program. The report, *PB 121495*, Part 4, J. S. Arnold, Stanford Research Institute for Wright Air Development Center, June 1956, may be ordered from OTS, U. S. Department of Commerce, Washington 25, D. C. It contains 45 pages, price $1.25.

SYMPOSIUM ON HIGH-PURITY WATER CORROSION. (ASTM Special Technical Publication *179*) Rising concern with corrosion problems makes this symposium of interest to corrosion engineers, nuclear engineers, and scientists interested in the phenomena associated with high-purity water and its corrosive effects under various conditions. Contained in the 56-page book are the following papers: "The Preparation and Maintenance of High-Purity Water," by F. N. Alquist; "The Use of Water in Atomic Reactors," by H. W. Huntley and S. Untermeyer; "Influence of Water Composition on Corrosion in High-Temperature, High-Purity Water." by D. M. Wroughton, J. M. Seamon, and P. E. Brown; "Effect of Material Composition in High-Temperature Water Corrosion," by A. H. Roebuck; and "Special Corrosion Study of Carbon and Low Alloy Steels," by R. U. Blaser and J. J. Owens. The volume is generously illustrated with graphs, diagrams, and photographs. Four of the five papers presented include bibliographies. The symposium was sponsored by ASTM Committee D-19 on Industrial Water and copies may be obtained from the American Society for Testing Materials (ASTM), 1916 Race St., Philadelphia 3, Pa., at $1.75 each.

CAREERS IN NUCLEAR SCIENCE AND ENGINEERING. Published by the Atomic Industrial Forum. The 34-page booklet is based on the proceedings of a conference for high school science students which was sponsored by the Forum and the Chicago Junior Association of Commerce and Industry, Chicago, Ill., in conjunction with the 1956 Trade Fair of the Atomic Industry and the Forum's annual conference on "Management, Economics and Technology for the Atomic Industry." The conference featured talks by Dr. Eric Walker, president of Pennsylvania State University; Dr. L. R. Hafstad, vice-president and director of Research of General Motors Corporation; and Dr. F. L. Hovde, president of Purdue University. The booklet also contains a transcript of a discussion period in which the speakers answered questions posed by the students. Approximately 1,400 selected students from public and parochial senior high schools in the Chicago area took part in the event, which included a special tour of the Trade Fair. The conference and the publication of its proceeding is part of the program of the Forum's Committee on Education and is designed to interest young people in scientific and engineering careers, essential to the development of sufficient technical manpower to meet the growing needs of this country's new atomic industry. Copies of the booklet are available at 10¢ each from the Atomic Industrial Forum, 3 East 54th St., New York 22, N. Y.

BIBLIOGRAPHY ON IGNITION AND SPARK-IGNITION SYSTEMS. By G. F. Blackburn, National Bureau of Standards (NBS) Circular *580*, issued November 1, 1956. This bibliography contains more than 425 references to books, papers, and reports on ignition and ignition apparatus in internal combustion engines. The material covered includes not only electric equipment for spark-ignition but also firing by means other than compression ignition. Circular *580* supersedes NBS Letter Circular *IC476, Bibliography of Spark Plugs*, and is wider in scope. The majority of the references were assembled in the course of investigations supported by the National Advisory Committee for Aeronautics, the Navy Bureau of Aeronautics, and other national defense agencies. 15 pages, 15¢, order from the Government Printing Office, Washington 25, D. C. Foreign remittance must be in United States exchange and should include an additional one third of the publication price to cover mailing costs.

PROCEEDINGS OF THE HIGH TEMPERATURE SYMPOSIUM. Stanford Research Institute has published the Proceedings of the High Temperature Symposium held June 25-27, 1956, on the Berkeley campus of the University of California. The conference was sponsored by the University of California and Stanford Research Institute. Cochairmen of the three-day session were: Leo Brewer, professor, Department of Chemistry, Chemical Engineering and Radiation Laboratories, University of California, Berkeley; N. K. Hiester, manager, Chemical Engineering Section, Stanford Research Institute; and A. W. Searcy, associate professor of Ceramic Engineering, University of California, Berkeley. Program section support was provided by the Air Force Office of Scientific Research, the National Science Foundation, the Office of Naval Research, and the office of Ordnance Research. The Proceedings, a hard bound volume consisting of 218 pages, contains papers by 36 internationally recognized authorities in high temperature. As a basic reference tool, the book is the most nearly complete work in print in the field. The three major subjects cover "Methods for Reaching High Temperatures," "Materials for Containing High Temperatures," and "Processes Occurring at High Temperatures." Written discussions of panel questions, prepared subsequent to the symposium, have been included in the Proceedings. Price is $5, postpaid, from the Public Relations Department, Stanford Research Institute, Menlo Park, Calif.

TENTATIVE REFERENCE PHOTOGRAPHS FOR MAGNETIC PARTICLE INDICATIONS ON FERROUS CASTINGS (*E 125-56T*). Discontinuities in iron and steel castings detectable by the dry powder magnetic particle method may now be classified by comparison with reference photographs recently published by the American Society for Testing Materials (ASTM). The photographs, showing indications observed on actual castings, have been reproduced through the courtesy of the Steel Founders' Society of America from photographs obtained from its member companies. Forty-seven reference photographs are included, covering linear discontinuities (hot tears and cracks), shrinkage, inclusions, internal chills and unfused chaplets, porosity, weld discontinuities, false indications, and magnetic anomalies. *E 125-56T*, containing explanations of the reference photographs and a set of four charts showing reproductions of the photographs, may be purchased for $2.50 from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

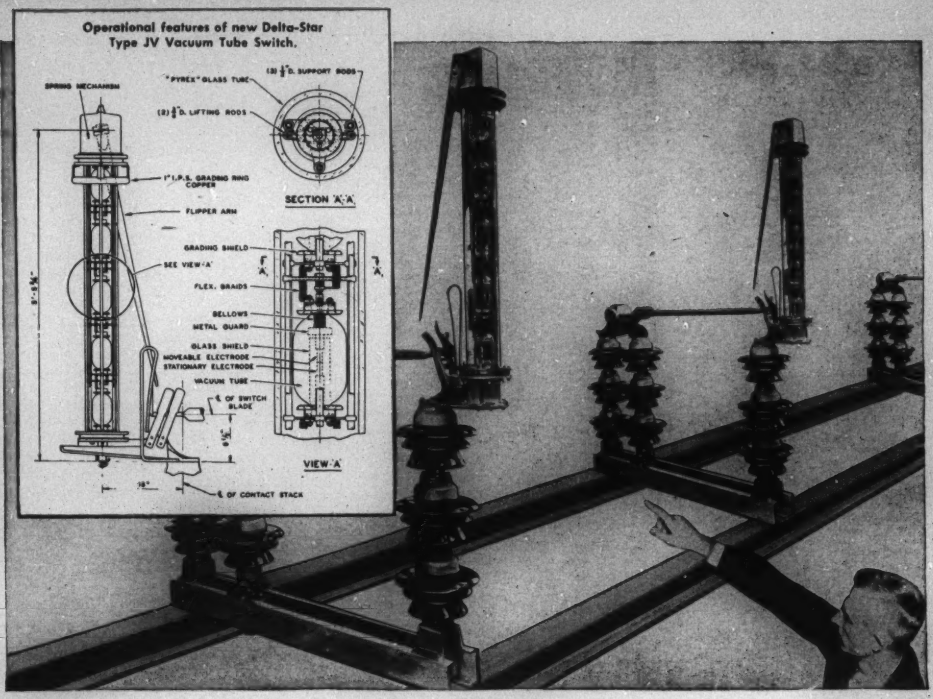
AIR CONDITIONING—REFRIGERATING DATA BOOK. Applications Volume, W. R. Woolrich, editor-in-chief; dean, College of Engineering; and director, Bureau of Engineering Research, University of Texas. Published by The American Society of Refrigerating Engineers (ASRE), 234 Fifth Ave., New York 1, N. Y., 1956. 1,100 pages, $10. This is a sixth edition, written by 90 experts, which contains 60 chapters. Complete revisions have been made in 8 chapters and moderate revisions in 26 chapters. Extensive changes in the bibliography have been made in two chapters. Most of the remaining chapters have been revised, to bring them up to date with latest practices. Authors and associate editors were chosen because of their experience and eminence in their particular fields. This method of selection plus the ASRE Technical Committee's critical review procedure insures that each chapter is the consensus of those best qualified for the job. This volume includes design information, formulae, tables, diagrams, and sample engineering calculations in factual handbook style presentation.

1957 REGISTRY OF INDUSTRIAL RADIO SYSTEMS. Revised annually from Federal Communications Commission (FCC) records, this new edition is now available for use by company officials, radio supervisors, and communication engineers. Part 1 lists all systems in the low-power industrial, special industrial, forest products, power utility, petroleum and gas, relay press, motion picture, and vhf maritime services, showing name and address of each licensee; location of each fixed transmitter; call letters; number of mobile units authorized; operating frequencies; and manufacturer of equipment used. Part 2, added this year for the first time, lists the licensees according to the transmitting frequency employed. This has been done at the request of the communication engineers and frequency coordinating committees. The new edition contains 153 pages, nearly twice as many pages as in the previous edition. Edited by E. V. Sleeper, these Registries have become a standard reference in radio communication, since the FCC does not put out any equivalent publication. Price $5. Other Registries, devoted to transportation, public safety, and common carrier systems, are published annually in March, June, and September, respectively. Available from Communication Engineering Book Company, Monterey, Mass.

IMC ELECTRICAL INSULATION MANUAL. This authoritative and useful guidebook to electrical insulating materials has just been published by the Insulation Manufacturers Corporation (IMC). The 300-plus page book is the first to describe and evaluate all of the commonly used insulations for electrical and electronic equipment in a single volume. The IMC Manual is sectionalized and tab-indexed for convenience in locating the 16 different chapters, each devoted to different types of electrical insulating materials. Original illustrations, drawings, specification tables, and graphs help the user to determine how well a specific product will solve his electrical insulation need. A complete alphabetical index and a guide to official standards for electrical insulating materials are also provided. The IMC Manual is available on request to users and specifiers of electrical insulating materials; price $5. Copies may be obtained by writing to the Publications Department, Insulation Manufacturers Corporation, 565 West Washington Boulevard, Chicago 6, Ill.

MANUAL OF CONSULTING PRACTICE FOR MECHANICAL ENGINEERS. Consulting engineers and their clients may now obtain copies of this new manual prepared by The American Society of Mechanical Engineers (ASME). The 14-page booklet includes sections on ethics, methods of establishing fees, selection of the right engineer for a particular job, and other subjects. It was prepared by the Committee on Professional Practice of Consulting Engineering of ASME. According to the announcement, the manual is intended to be of equal value to engineers and their clients. Its purpose is to help eliminate possible misunderstandings by providing basic information on the engineer—client relationship in general and outlining rules to cover such items as delay or termination of engineering projects, ownership and reuse of plans, ownership of patents, and protection of confidential information. Canons of ethics included in the manual were originally issued by Engineers Council for Professional Development and have since been adopted by ASME and other leading engineering societies. They provide rules of conduct for the engineer in dealing with the public, clients, and other engineers. Copies of the manual are available from the ASME Order Department, 29 West 39th St., New York 18, N. Y., at $1.50 each.

TRANSISTOR ENGINEERING REFERENCE HANDBOOK. The state of development in the manufacture of transistor and transistor circuits has brought about increasing application of these devices in power control, communications, industrial manufacturing, consumer use, and numerous branches of engineering and scientific research. A large number of technical articles and an increasing number of excellent books have appeared, mainly on the theoretical and experimental uses of transistors. However, only a few scattered summaries of the commercial status of the transistor industry may be found in the literature. The need for a single book to assemble and co-ordinate all of the commercial aspects of the transistor art has come into being. The handbook presents the unabridged details on some 200 different types of transistors. In addition to the constant and characteristic curves, all of the performance data will be on types already available. Among the components designed for transistorized equipments presented in this book are almost 200 transformers, 450 capacitors, more than 100 cells and batteries, a selection of thermistors, and a variety of miscellaneous components. This is by far the most complete tabulation ever presented to aid the engineer. The engineer and engineering student who is just beginning to look into the details of transistor circuits will find the general transistor story to be compact and right to the point, with a selected bibliography to guide him in almost any direction he chooses to take. The text portion of the handbook dealing with the physical nature of transistors includes the point contact structure, field effect, fieldistor, analog, antianalog, filamentary, junction avalanche, surface barrier, intrinsic barrier, and diffused layer types, and includes circuits recommended by the producers of these devices as well as the fruits of research effort. The bibliography on circuitry has been selected to represent the more recent design approaches. The section of the book which lists the specification and, in many cases, schematics of more than 100 commercial applications, can serve many purposes. To the research worker it can be a convenient check on the trend toward practical applications. To the industrial designer it affords package circuits that he can quickly adopt for his purposes. To the engineering student it can be a way of checking some of his design calculations; to engineering aids and technicians it will serve as a reference. The last section of the book also lists the names and addresses of the manufacturers whose products are discussed and listed in the book. It is emphasized that this is not a theory book. Rather, it is intended to serve all who are seeking answers to the design and supply problems concerning transistors and related components, as related to all fields of effort. This book contains 288 pages, clothbound. The Handbook is written by H. E. Marrows, Catalog No. 193, List Price $9.95. Order Copies from John F. Rider Publisher, Inc., 116 West 14th St., New York 11, N. Y.



DELTA-STAR Announces NEW High Voltage MKV-40 Interrupter Switch

Provides positive current interruption for load and capacitor switching.

The new Delta-Star MKV-40 Interrupter Switch is especially well suited for switching capacitive loads. A series of vacuum switches having extremely high dielectric strength does the job. Ratings 34.5 kv to 138 kv are now available.

Vacuum switches are in the circuit only during the interrupting cycle. Interruption occurs at first current zero with no restrikes. Jennings vacuum switches used in this device require no maintenance.

Get all the facts about this new Delta-Star switch from your nearest representative. Or, write *Delta-Star Electric Division, H. K. Porter Company, Inc., 2437 Fulton St., Chicago 12, Ill. Offices in principal cities.*

HKP DELTA-STAR ELECTRIC DIVISION

H. K. PORTER COMPANY, INC.

Divisions of H. K. Porter Company, Inc. are: Alloy Metal Wire, Connors Steel, Delta-Star Electric, Henry Disston, Lacledo-Christy, Leschen Wire Rope, McLain Fire Brick, Quaker Pioneer Rubber, Quaker Rubber, Riverside Metal, Vulcan Crucible Steel, W-S Fittings.

TEST YOUR
IQ*
(*Insulation quotient)

Identify an outstanding dielectric which has the following characteristics:

1 A tensile strength of better than 28,000 P. S. I.

2 A high impact strength.

3 Is available in machined components, sheets and rods up to *13 feet long* and *5 inches thick*.

4 Costs less than many conventional materials.

The only CORRECT ANSWER YOU CAN GIVE IS

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If you "flunked" the test, and would like to learn more about PERMALI, how it can improve your operation and cut your costs, then write for literature . . . no obligation.

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"STRENGTH WHERE YOU NEED IT"

INDUSTRIAL NOTES

Fairchild Division Moves. Fairchild Camera and Instrument Corporation's Electronics Division has moved into its new headquarters on Aerial Way North in Landia Industrial Park, Syosset, L. I., N. Y. Departing from its old facilities at 200 Hudson Street in New York, N. Y., it leased a new 15,000-foot building adjacent to the company's Scan-A-Plate plant and the company's main plant which houses the corporation's executive offices plus the Reconnaissance Systems Division, largest of Fairchild's seven operating divisions. The building houses the latest available research and test equipment. It includes a complete technical library, an ultrasonic laboratory, a laboratory dark-trace tube and allied electronic experimentation, other electronic development laboratories, experimental and photo darkrooms, and two design and drafting sections.

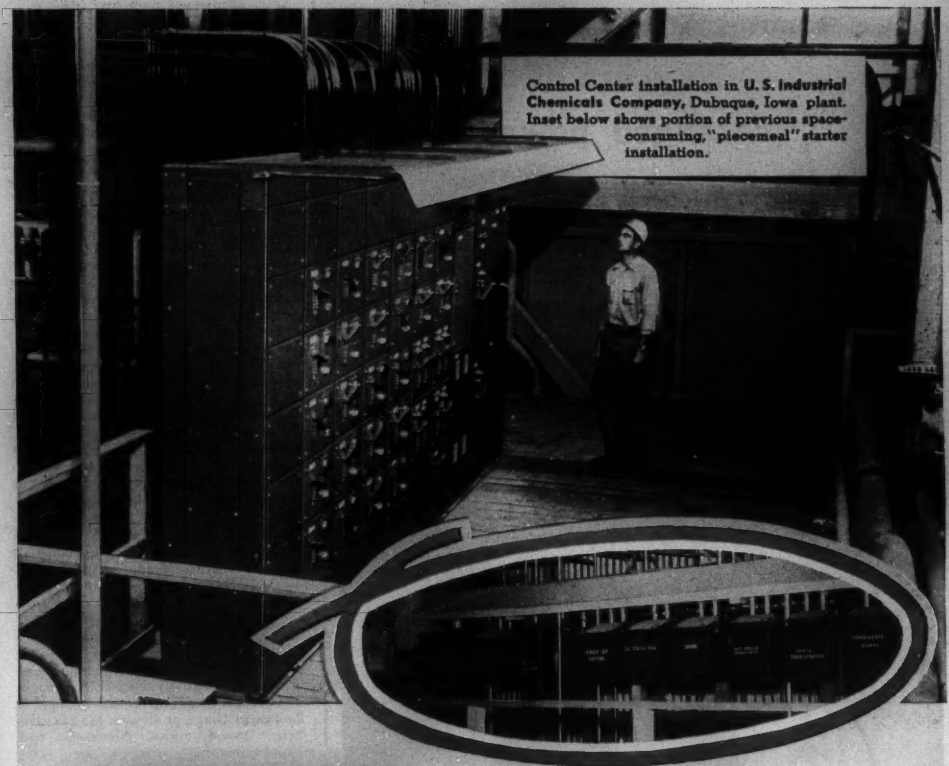
Nuclear Power Equipment Division. A new division of Kieley & Mueller, Inc., Middletown, N. Y., manufacturer of automatic control valves, power, and steam specialty equipment, is being staffed by specially trained and experienced personnel from both the automatic control and nuclear fields. Mr. Russ Woods, formerly associated with the Knolls Atomic Power Laboratory, recently joined the company in anticipation of the establishment of this new division. Shortly following this announcement it was revealed that the Nuclear Power Equipment Division had been awarded three-quarters of a million dollars in valve contracts. For use in the nuclear powered propulsion field, special ultrahigh temperature, bellows-sealed control valves complete with self-contained control systems are to be built by the new Kieley & Mueller division for a nuclear development facility. Stronger emphasis on nuclear control products is a normal step for the company which has been continually active in power field developments since its founding in 1879.

Link Aviation, Inc. Plans to open a laboratory at Palo Alto, Calif. have been announced. This operation will be under the general supervision of E. D. Hilburn, manager of the Western Division of Link. The research facility will be located at 530 University Ave., Palo Alto, Calif. Link Aviation, Inc., pioneer manufacturer of flight training equipment, selected Palo Alto as the site for this expansion of its engineering facilities because of the area's growing importance as a center of scientific and industrial research activities. Another reason for locating at Palo Alto is that Link engineers employed there may avail themselves of the many opportunities to obtain advanced degrees at Stanford. Additionally, the opening of this laboratory will make possible closer coordination between Link and the aircraft and missile manufacturers located on the West Coast. Projects to be carried out at the new laboratory will include design and development work on advanced electronic computing systems, transistor circuits and guided missile test systems.

Industrial Television Control System. A single-cable industrial television control system that combines both visual observation and remote control throughout a plant over a closed-circuit television system has been introduced by the Jerrold Electronics Corporation, 23rd and Chestnut Streets, Philadelphia, Pa. A unique feature of this system is its ability to carry all functions such as two-way pictures, two-way communications, and remote control, on a single coaxial cable. Previously, a separate cable had been required to carry each of these functions. This Jerrold Corp. system permits the use of virtually any closed-circuit television camera. Cameras of different manufacture can be mixed in the same system and plugged in at any point. While featuring multiple inputs, it also offers an unlimited number of outputs to commercially available television receivers. The system can integrate any of the presently available supervisory control equipment, which can select cameras remotely and adjust them to show the desired picture. Since the system will provide an outlet in every key area of a factory, various departments can make use of the same camera at different times during the day. The camera that is used by the safety engineer for an area study in the morning can be moved to a new location by the public relations department for part of a plant tour in the afternoon, while the night watchman can make use of it at still another location in the evening. No matter where the camera is plugged into the system, it can be controlled by the user from the point that is most convenient for him.

Spacious New Plant. Chart-Pak, Inc., will move its entire production facilities and executive headquarters to a spacious new plant now under construction in Leeds, a suburb of Northampton Mass., early this Winter. The company manufactures visual aids for use in making graphs, organizational and flow charts, plant and office layouts, printed circuits, as well as other graphic and pictorial materials commonly used by statisticians, accountants, engineers, architects, and draftsmen. The Chart-Pak method uses standardized symbols and shapes printed on adhesive backed pressure sensitive tapes or sheets. The new one-story structure would be four times the size of the present plant. It is being built on a four acre site in Northampton, Mass., a city of 30,000. The construction of the building and the size of the site will facilitate future expansion. The rear wall of the new building was designed to allow for expansion of the building at a minimum cost and with no disruption of production.

(Continued on page 24A)



Control Center installation in U. S. Industrial Chemicals Company, Dubuque, Iowa plant. Inset below shows portion of previous space-consuming, "piecemeal" starter installation.

"COMPARISON convinced us that a SQUARE D Control Center offered us MORE!"

These design features make Square D your logical choice, too...

INCREASED SAFETY because bus bars are fully enclosed, rigidly supported and have ample cross section. Circuits are isolated by individually enclosed plug-in units. Disconnect handle designed for maximum operator protection.

FLEXIBILITY. Individual plug-in units or complete sections are easily added, removed or exchanged. Pushbuttons, pilot lights, and selector switches are readily added to unit doors.

INSTALLATION ECONOMY. All wiring channels are large and accessible from front without removing units. No "wire fishing."

SPACE ECONOMY, TOO. Up to six combination starters fit in a 20" x 20" x 90" section. Plug-in unit heights designed in space-saving increments of 3 inches.

NOW...EC&M PRODUCTS ARE A PART OF THE SQUARE D LINE!

SQUARE D COMPANY

control batteries are built for

25 years of

"packaged power"

At Weyerhaeuser Timber Company, switchgear control batteries in Everett, Wash., sulphite mill are C & D PlastiCal® —the batteries built for control . . . and to last 25 years.

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Not just "batteries"! These are *engineered* C & D PlastiCal® (lead-calcium) control batteries—batteries specifically designed for switchgear, control, and auxiliary power service —batteries built to deliver high, steady output with only minimum maintenance *for the next quarter-century!*

Weyerhaeuser Timber Co., big suppliers of woodpulp to the paper and allied industries, wanted more than just batteries. Their choice: C & D PlastiCal®—the control batteries with the "more battery for the money advantages."

See why

For details, send for Bulletin CP-536. Find out about the battery of tomorrow—today!

C&D BATTERIES, INC.

of Conshohocken, Pa.

Since 1906

Sales and service offices in principal cities from coast to coast

(Continued from page 20A)

Industrial Notes

Aluminum-Clad Copper Wire. A thin, protective aluminum "skin," only two and a half mils thick, has been placed on copper wire by Westinghouse engineers. The skin promises to increase the life, reduce the size and raise the efficiency of present-day electrical equipment by allowing it to operate over long periods of time at higher temperatures than are now practical. In a new metallurgical technique, the wire is encased in a thin, protective coating of aluminum, to which is then added a second coating of high-temperature insulation. The result is an enameled aluminum-clad copper wire that combines the high electrical conductivity of copper, the superior oxidation resistance of aluminum, and the added protection of modern insulating enamel. In almost every application encountered, from jet planes and guided missiles to routine jobs in industry, electrical apparatus is called upon to operate at ever-increasing temperatures. Such temperatures tend to destroy what are usually the most sought-for properties of materials, such as strength and chemical inertness.

Fluorescent Lighting Clinics. Clinics are being conducted by lighting specialists of Sylvania Electric Products Inc., in 11 major cities of the United States this winter. A team of lighting specialists from the company's Lighting Division headquarters here and from the company's sales districts, are participating in the clinics in the Midwest, Far West and South. Heading the specialist group is T. C. Sargent, staff commercial engineer of fluorescent lamps, at division headquarters here. Demonstrations, discussions, and "trouble-shooting" sessions are being scheduled with local groups in each of the areas. Problems of installations, specifications, and design features of various types of fluorescent lamps and fixtures are covered in the meetings. A feature of the clinics is a demonstration of Sylvania's newest fluorescent development, the very high output lamp which provides more than twice the light output of conventional fluorescent lamps. This new development is described as a completely new fluorescent lamp development which goes beyond any previous achievements in high intensity fluorescent lamp sources.

Million-Watt Television Station. Complete Radio Corporation of America (RCA) live and film color television camera systems have been purchased for immediate delivery by the nation's first million-watt uhf television station, was announced by WBRE-TV, Wilkes-Barre, Pa., and the broadcast and television equipment department, RCA. Installation of the RCA camera chains will make WBRE-TV the world's most powerful broadcast station with facilities for originating live local color television programs. The Channel 28 station also will be the first television outlet in the Wilkes-Barre area equipped to originate local colorcasts.

(Continued on page 28A)

Anaconda specifies Enjay Butyl rubber

TO DEFY OZONE IN HIGH-VOLTAGE CABLES...

for more current per circuit...more power per dollar

Anaconda specifies Enjay Butyl insulation for high-voltage cables because this rubber has incredible resistance to ozone. Surpassing the industry's standard three-hour specification test, Enjay Butyl insulation used by Anaconda showed *no injury after 72 hours* of ozone concentration tests—24 times longer than specification requirements. Other rubbers would deteriorate and crack in a fraction of this time.

With the help of Enjay Butyl, millions of feet of Anaconda's cable now in use deliver more current per circuit, more power per dollar.

Perhaps *your* product, too, can be improved with versatile Enjay Butyl. It comes in non-staining grades for white and light-colored parts, offers excellent electrical properties, low price and *immediate availability*. For full information, contact the Enjay Company. Complete laboratory facilities and technical assistance are at your service.

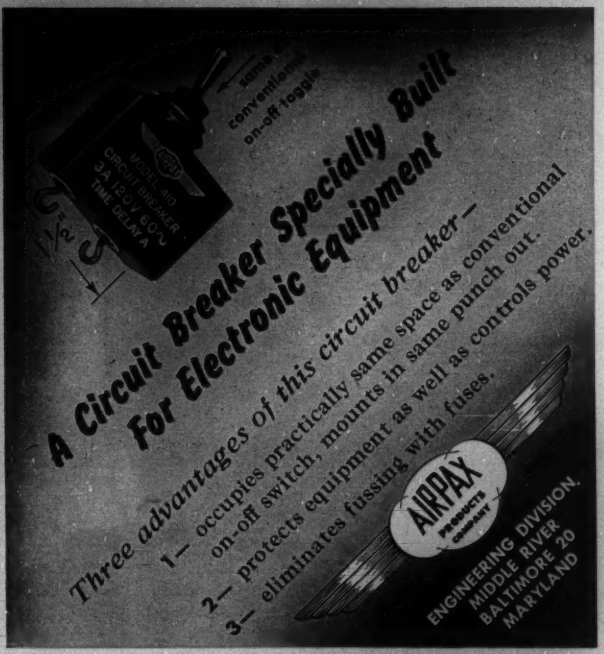
ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture.

ENJAY *Pioneer in Petrochemicals*

ENJAY COMPANY, INC., 15 West 51st Street, New York 19, N. Y.

Other offices: Akron • Boston • Chicago • Los Angeles • Tulsa


A Circuit Breaker Specially Built For Electronic Equipment
Three advantages of this circuit breaker—
1— occupies practically same space as conventional on-off switch, mounts in same punch out.
2— protects equipment as well as controls power.
3— eliminates fussing with fuses.
same as conventional on-off toggle
AIRPAX PRODUCTS COMPANY
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BALTIMORE 20
MARYLAND

FOUR-CHANNEL CARRIER-TELEPHONE TERMINAL FOR RADIO LINKS

This is a miniaturized unit of advanced design which provides four voice channels on a frequency-division basis above a voice-frequency order-wire channel. Each of these five channels is provided with a 4-wire 2-wire termination and a voice-frequency ringing circuit for d-c or 20-cycle signals. Adjustable attenuators are provided in the 4-wire side of all channels, and a built-in test oscillator and meter permit complete line-up, maintenance and trouble-shooting checks to be made. Channel levels are from −9 to 0 dbm and line levels from −30 to 0 dbm. Channel width is 300 to 3500 cycles within 1 db.

This unit is only 5¼" high by 19" wide by 14" deep. It mounts on a standard rack and operates from 115 volts 50-60 cycles a.c.

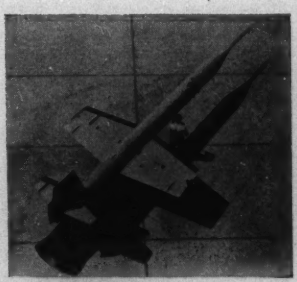
RADIO ENGINEERING PRODUCTS
1080 UNIVERSITY ST., MONTREAL 3, CANADA
TELEPHONE UNiversity 6-6887
CABLES RADENPRO MONTREAL

(Continued from page 24A)

Industrial Notes

Silent Sound Waves. American industry, led by the Air Force, Navy, and Atomic Energy Commission, will buy more ultrasonic equipment in 1957 than in all previous years, it was predicted at an ultrasonics symposium held at the Yale Club, New York, N. Y. However, artificial barriers threaten to slow future progress unless industry takes co-operative action now. The market for industrial application of ultrasonics, silent but remarkably powerful sound waves, will undergo a threefold expansion in the next 12 months. "Silent" sound waves will drill odd-shaped holes in diamonds, glass, and other hard materials, sound waves will clean and degrease precision equipment faster than any other method, microscopically clean and sterilize surgical instruments immersed in cold water, decontaminate radioactive objects, solder aluminum in the absence of flux, dye fabrics, sense the liquid level in a tank, ferment beer, detect hidden flaws in metal, detect tumors in the human body, and treat arthritis.

Missile Flight Control System. Lear, Inc., has been given permission by the United States Air Force to disclose that the flight control system for Lockheed's *X-7* missile, a supersonic ramjet-powered test vehicle, has been supplied by Lear since inception of the project in 1949. After launching from a *B-29*, and after being accelerated to ramjet operating speed by rocket, this missile performs its prescribed test mission and then is decelerated and recovered by



parachutes. After servicing, the control system normally is ready for another flight. Thus, the missile's flight control system not only had to meet Lockheed and Air Force requirements for control at high altitudes and speeds, but also had to withstand severe shocks of repeated recoveries without damage. Existence of the *X-7* was revealed several months ago by spokesmen of the Air Research and Development Command.

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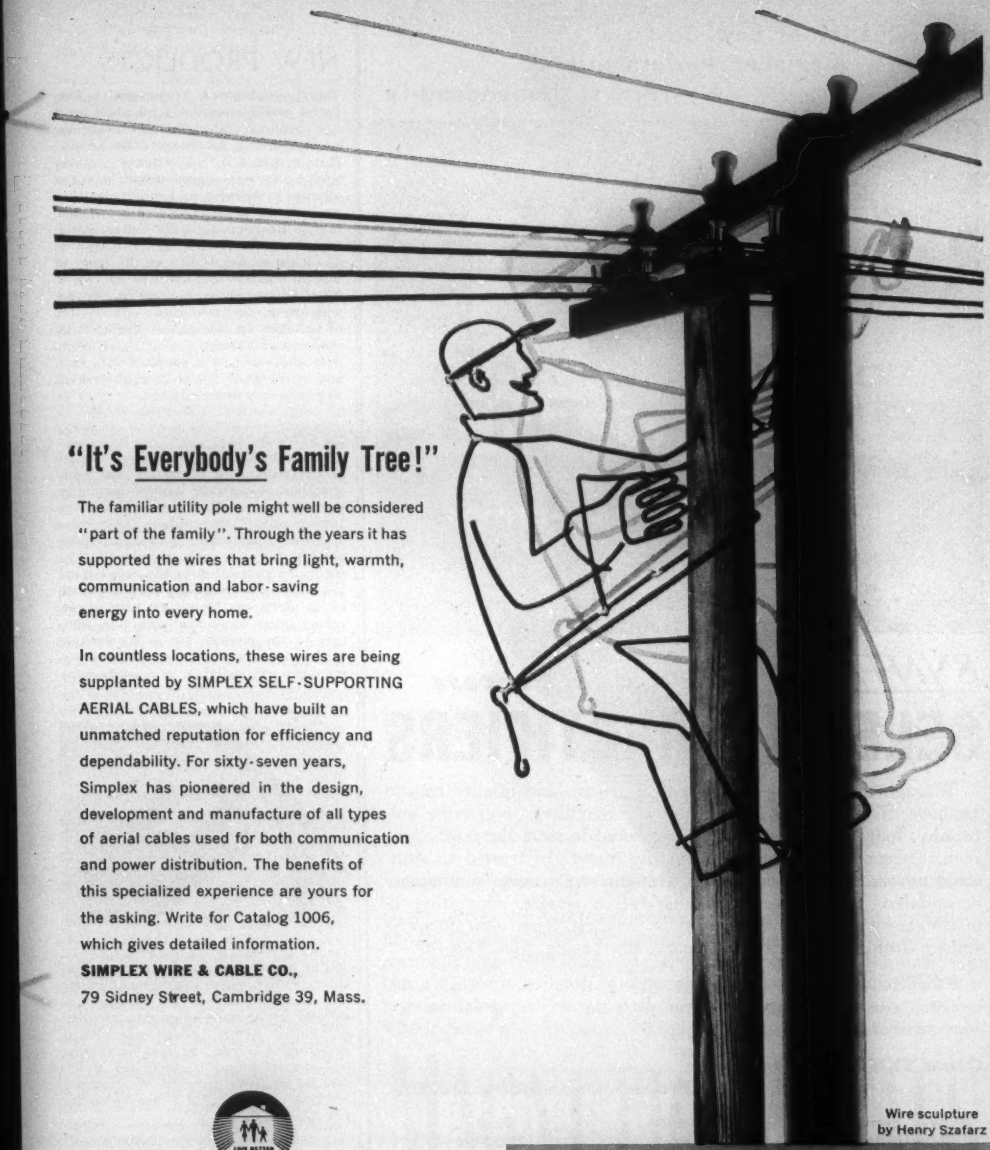


"It's Everybody's Family Tree!"

The familiar utility pole might well be considered "part of the family". Through the years it has supported the wires that bring light, warmth, communication and labor-saving energy into every home.

In countless locations, these wires are being supplanted by SIMPLEX SELF-SUPPORTING AERIAL CABLES, which have built an unmatched reputation for efficiency and dependability. For sixty-seven years, Simplex has pioneered in the design, development and manufacture of all types of aerial cables used for both communication and power distribution. The benefits of this specialized experience are yours for the asking. Write for Catalog 1006, which gives detailed information.

SIMPLEX WIRE & CABLE CO.,
79 Sidney Street, Cambridge 39, Mass.

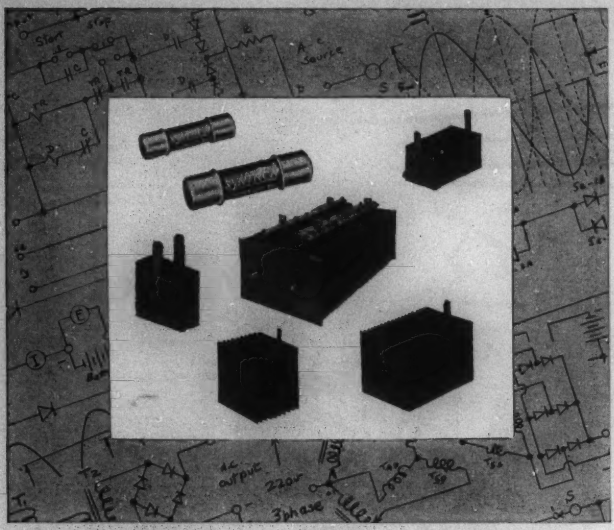
LIVE BETTER ELECTRICALLY

Simplex

Wire sculpture by Henry Szafarz

Anhydrex Insulated, Neoprene Jacketed, Self-Supporting Aerial Cable

High Quality at Low Cost
Maximum Performance
Proven Dependability



SYNTRON **Vacuum Process**

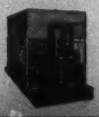
SELENIUM RECTIFIERS

Through their unique vapor deposit process and quality control methods, SYNTRON is able to provide Rectifiers of extreme uniformity, long life and stability. Engineered to meet the most rigid requirements. Constructed from quality materials, treated to withstand adverse climatic conditions. Designed to provide continuous, dependable, trouble-free, maintenance-free service. Operation is instantaneous, no warm-up period is required. Their low forward voltage drop means greater efficiency, low ageing, and long life.

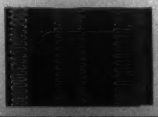
SYNTRON produces the largest variety of selenium cells in the industry. Let our applications engineers make recommendations for your rectifier needs.

Other SYNTRON Equipment of Proven, Dependable Quality

Power Conversion Units



Sinuated Wire



Parts Feeders

SYNTRON COMPANY
440 Lexington Avenue Homer City, Penna.

Write for complete catalog data—Free!

(Continued from page 28A)

NEW PRODUCTS

Variable Calibrated Attenuator. A long life of accurate service is promised for a new precision calibrated attenuator announced by the Admittance-Namco Corp., Farmingdale, L.I., N.Y. Featuring a very simple and very rugged design, it is not affected by changes in humidity or temperature variations. The accuracy at calibration frequency is 0.2 db. Voltage standing wave ratio (VSWR) at the maximum 40 db attenuation is 1.15. In the range of 0.20 db insertion it is less than 1.1 VSWR. This attenuator is micrometer driven, with the driving mechanism entirely free of backlash. Its dissipative element is an evaporated nichrome film on a glass plate. A calibration chart is supplied with each instrument and it can be calibrated at any frequency upon request.

"Zippertubing." Time and labor costs are greatly reduced in the lacing and tying operation of electrical harness assemblies, through the use of a zipper-style plastic tubing, called "Zippertubing." Air Force approved, zippertubing is used to enclose, identify, and protect multi-conductor wiring in the aircraft, electronic, or electrical industries. The simplicity and ease with which wiring can be encased with zippertubing offers many applications in addition to the primary use as a substitute method for lacing and tying, such as wiring ducts, wire marking (in short lengths),

and as a replaceable cable jacket to protect expensive custom cables from abrasive wear. Custom cabling for experimental use also can be made up quickly, avoiding prohibitive factory set-up costs. When zippertubing is used, the need for dilating conventional tubing is eliminated. Bulletins are available from W. A. Plummer Manufacturing Co., 752 S. San Pedro St., Los Angeles, Calif.

Thermostat. The Klixon snap-acting, disc-type thermostat for applications where maximum shock and vibration resistance are required is presented by the Spencer Thermostat Division of the Metals & Controls Corporation in Attleboro, Mass. These controls feature the Spencer disc thermal element, fine silver electric contacts, and a complete hermetically sealed

(Continued on page 55A)

(Continued from page 30A)

New Products

assembly. A copper-nickel plated steel casing protects all parts from contamination and moisture to assure precise circuit operation. Applications are especially recommended in aircraft controls and guided missiles. A wide range of possibilities also exists in heaters, electronic circuits and components, servomechanism, gyroscopes, aerial cameras, gun mounts, etc.

Sonic Gas Analyzer. This analyzer employing the velocity of sound and offering exceptional range, sensitivity, and rapidity of analysis, has been released by the National Instrument Laboratories, Inc., 6108 Rhode Island Ave., Riverdale, Md. The monitoring of gas mixtures by continuous or batch control, the detection of minute amounts of harmful gases in pollution or personnel safety problems, vapor and gas chromatography, and the study of isotope concentration in certain gases are a few of the sonic gas analyzer's many applications. Developed by Merck & Co. and tested in a variety of industrial and physiological applications, the analyzer exploits the wide difference in sonic velocity by achieving such measurable sensitivities as 0.005 per cent of oxygen in air and 0.00061 per cent of hydrogen. The single chassis construction of the basic unit permits its installation in industrial plants where other apparatus is too delicate or too insensitive. No prolonged manipulation or procedures stand in the way of rapid calibrations or of reading the inherently instantaneous response. The easy operation of the instrument will appeal especially to the cost-conscious engineer and busy laboratory technician.

Switch for Calculators. A slim pushbutton switch for computers, calculators, and similar electrical and electronic devices using whole banks of adding machine type key switches has been announced by Hetherington, Inc., 1200 Elmwood Ave., Sharon Hill, Pa. Known as Type *B5023*, the new momentary-contact switch has a smooth, yet precise, nonsnap action that closely approaches the speed of operation and convenience of mechanical type pushbuttons long used on calculating machines. The switch responds to an operating pressure of only one-half pound and has a total button travel of one-fourth inch. Contact arrangement is two-circuit, break-before-make. The entire switch mechanism is housed in a dust- and moisture-resistant anodized aluminum case. Complete specifications on the *B5023* switch are available on request to the manufacturer.

Copper Clads. Photosensitized copper clad sheets are available to manufacturers and laboratories as announced by Keil Engineering Products, 4356 Duncan Ave., St. Louis 10, Mo. With these sheets any

(Continued on page 59A)

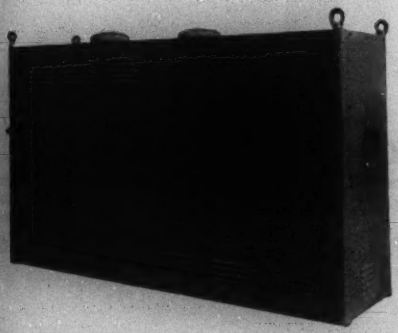
CENTRICORES are processed from thinner gauge materials including Hymu, Squaremu "79", Squaremu "49", Microsil and "49" Alloy for magnetic amplifier and special transformer applications. New sizes are being constantly added to standard sizes available from stock for prompt delivery. *Write for Bulletin C-1* covering magnetic properties. Also indicate where Magnetic Amplifier test procedure data is desired.

MAGNETIC METALS COMPANY

Electromagnetic Cores and Shields

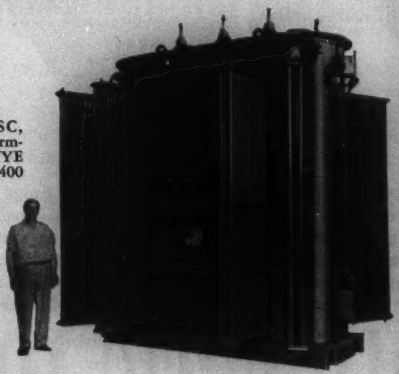
Hayes Avenue at 21st Street, Camden, N.J.

PLANNING
KEEPS YOU AHEAD OF POWER NEEDS



300 KVA indoor unit substation or load center consisting of high voltage fused air break switch and low voltage section with circuit breakers and metering.

Good planning, with the aid of Standard Transformer Company engineers, will help you stay ahead of your expanding power needs. Standard will work with you to design and build the custom transformers which meet your needs best, and you'll pay no more than you pay for repetitive models. Check with Standard now. Just tell us your present and anticipated needs. Your inquiries will receive immediate attention.



7500 KVA, OISC, three-phase transformer, 34,400 volts WYE primary, 4180Y/2400 volts secondary.

THE Standard®

WARREN, OHIO
REPRESENTATIVES IN PRINCIPAL CITIES

Telemeter ANY VARIABLE from Remote Points

Accurate, Fast Acting, Frequency Type Telemeter for Transmission over Wire Lines, Microwave, and Power Line Carrier

Accurate HIGH-SPEED Continuous Telemeter

for

VOLTS
AMPS
WATTS
VARS
ETC.

•

Built-in Self-Calibrating Circuit

•

The Model 1025 Telemeter Transmitter converts DC mv from thermal converters, etc., to 10-30 cps which frequency modulates a built-in audio tone channel. AC 10 to 30 cps or relay outputs are also available. Receiver detects and demodulates transmitted signal, generating a DC mv for operation of recorders or indicating instruments. Up to 45 telemeters can be multiplexed.

Any communication link, including power line carrier, microwave or wire line may be used.

Over-all accuracy is 1% with a response speed of 1 second. Equipment features a built-in calibration circuit for 10% and 90% receiver check, and 10 cps and 30 cps transmitter check.

Any quantity which may be converted into a DC millivoltage or will operate a slidewire may be telemetered.

WE CAN HELP YOU
Our Applications Department is ready to assist you in your control, telemetering or communications problem. Phone DEerfield 4-3100.

Write for Technical and Application Data.

Radio Frequency LABORATORIES, INC.
Boonton, New Jersey, U. S. A.

(Continued from page 55A)

New Products

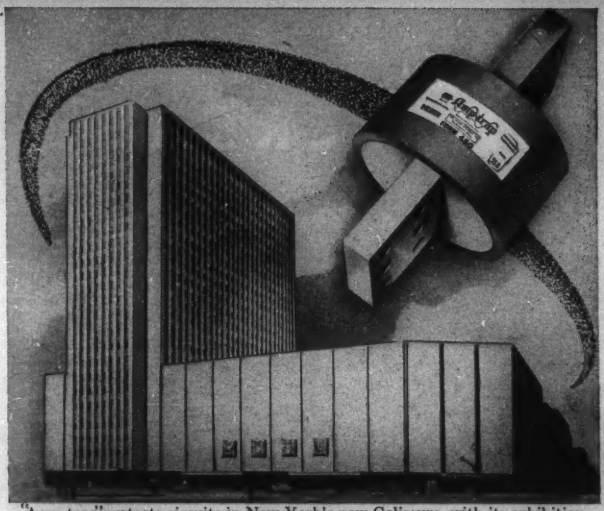
etched circuit panel may be produced in any quantity on the user's premises. Processing chemicals and supplies are also available, or may be purchased locally. The sheet are available in any rectangular size desired up to 18 inches by 21 inches. This method of processing produces circuit boards to satisfy the most critical applications. Extremely fine circuit detail and exact circuit reproducibility is obtainable. Requirements on the part of the user necessitate only exposing, developing, and etching to a finished panel. Large sheet sizes allow the preparation of more than one circuit panel simultaneously. Sample quantities for experimental and prototype use may be obtained in kit form which supplies the presensitized sheet, all processing chemicals, and handling equipment. Full instructions for processing are included with all materials.

Fuseholder and Fuse. This fuseholder, in combination with indicating fuse, flashes a light, rings a bell, trips a relay, or gives other signals, to tell when or where a fuse blows. The fuseholder and fuse can be used where it is desirable to have a visible or audible signal to indicate trouble on the circuit. Possible applications include many types of testing equipment, control circuits, control panels, switchboards, and calculating or computing machines. Made by Bussmann Mfg. Co., division of McGraw Electric Co., University at Jefferson, St. Louis 7, Mo.

S-Band Cavity Oscillator. The *500* series cavity oscillator for either pulse or continuous wave operation has been designed and produced by Amerac, Incorporated, 116 Topsfield Road, Wenham, Mass. This is a miniaturized, grid separated, double coaxial line cavity oscillator, utilizing the *GL-6442* tube. It is especially suitable for aircraft, guided missile and beacon applications, due to its light weight and mechanical strength. It has a high operating efficiency under severe shock and vibration conditions. As a pulse cavity oscillator, it has a tuning range in excess of 200 mc in the S-band region with a peak power output of one kilowatt in upper range and two kilowatt in lower range, operating under a duty cycle of 0.001. Its plate voltage is 2,000 at 4 amperes. As a continuous wave cavity oscillator, it has a tuning range in excess of 200 mc in the S-band region with a power output of 50 megawatts in upper range and 100 megawatts in lower range.

Nails for Harness Board. A line of nails designed specifically for harness board wiring applications has been announced by John Hassall, Inc., Westbury, N. Y. In addition to having extensive applications in the electric and electronic fields, these nails will find broad usage in the aircraft and guided missile industries, in wiring

(Continued on page 60A)



"Amp-trap" protects circuits in New York's new Coliseum, with its exhibition halls and amphitheatre, against the danger of heavy short-circuit or fault currents, regardless of varying load requirements.

SHAWMUT'S FORM 480 Amp-trap®

FOR APPLICATION ON ENTRANCE SWITCHES, BUSWAYS, FEEDER SERVICES AND CIRCUIT BREAKERS
ON AC CIRCUITS UP TO 600 VOLTS
ON DC CIRCUITS UP TO 250 VOLTS

- Positive Protection against Super currents as high as 500,000 peak amperes available.
- Built in Ampere Ratings of 600, 800, 1000, 1200, 1600, 2000, 2500, 3000, 4000, 5000 and 6000.
- Sharp Current Limitation Characteristics for Backup Protection of Air Circuit Breakers, Switches, etc.
- Easily Adaptable into Busses, Bus Ducts or Switches.
- Economical in First Cost and Replacement.
- Very Low Watt Loss — Cool Operation.

Copyright 1957, The Chase-Shawmut Co.

OVER 60 YEARS

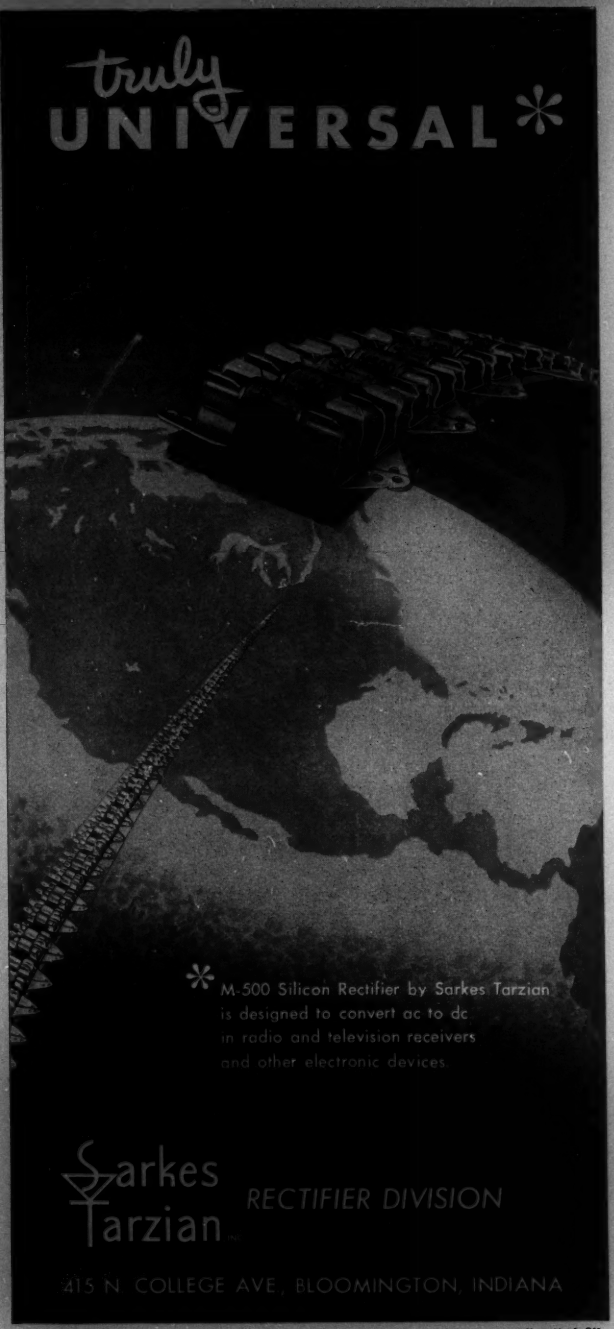
480-Amp-trap® — "Awake At The Switch"

THE CHASE-SHAWMUT CO.

373 MERRIMAC STREET • NEWBURYPORT, MASSACHUSETTS

Subsidiary of I-T-E CIRCUIT BREAKER CO., Philadelphia, Pennsylvania

truly UNIVERSAL*



* M-500 Silicon Rectifier by Sarkes Tarzian is designed to convert ac to dc in radio and television receivers and other electronic devices.

Sarkes Tarzian RECTIFIER DIVISION

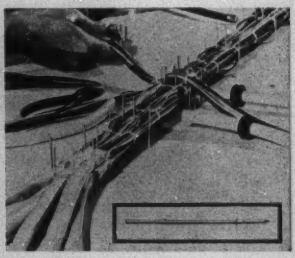
415 N. COLLEGE AVE., BLOOMINGTON, INDIANA

In Canada: 700 Weston Rd., Toronto 9, Tel. Rogers 2-7535 • Export: Ad Auriema, Inc., New York City

(Continued from page 59A)

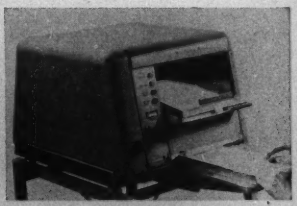
New Products

machine-tool control panels, for instrument and control wiring, for switchboard wiring, in short, wherever multiple circuits are preassembled prior to installation within the main piece of equipment. The nails, or posts, have a collar-type stop five-eights inch from the pointed end to prevent them from being driven in too far. The collar also acts as a guide in



assuring that they will be driven in far enough. The posts are driven directly into the board without the aid of predrilled holes. Tops are milled round to facilitate slipping wires on and off the harness. Nails are made of corrosion-resistant cadmium-plated steel. For additional information on these harness board posts, write to the manufacturer.

Camera. A compact, duplex microfilm camera that photographs both sides of a document simultaneously at any of three reduction ratios has ben developed by Remington Rand Division of Sperry Rand Corporation, 315 Fourth Ave., New York 10, N. Y. The unit has a 12-inch throat, and doubles 16-mm film capacity by filming up one side and down the other using the 8mm principle. Readily interchangeable lenses are available for 25 to 1, 35 to 1, and 42 to 1 reduction ratios. At the 42 to 1 ratio, the Model *11* films a greater



number of documents per roll of film than any other microfilm camera now available. Full operating controls, warning buzzer, and indicator lights assure simple, error-free microfilming with no special operator training needed. Light intensity

(Continued on page 62A)

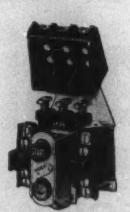
The Sign of
QUALITY
MOTOR CONTROL

ALLEN-BRADLEY
TROUBLE FREE MOTOR CONTROL

Here are the 3 most popular Allen-Bradley starters. They are QUALITY products widely associated with QUALITY machines. Machine tool builders and buyers appreciate the trouble free operation of A-B motor controls. Send for your copy of the A-B Handy Catalog.

BULLETIN 609 MANUAL ACROSS-THE-LINE STARTERS UP TO 5 HP, 220 V; 7½ HP, 440-550 VOLTS

A Kindt-Collins Master profile grinder equipped with an A-B Bulletin 609 manual starter and an A-B Bulletin 807 drum switch.



Allen-Bradley drum switches come in many styles and ratings. Send for bulletin.

Bulletin 609 arc hood lifted to show the contacts.

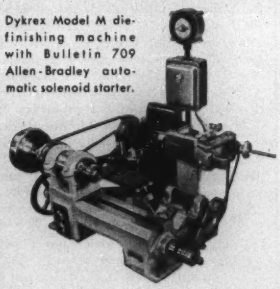
These Bulletin 609 manual starters are popularly used on motorized machines where no safety hazard to workmen is created if the machines should start unexpectedly, after a power interruption.

The quick-make, quick-break switch has double break, silver alloy contacts which require no maintenance.

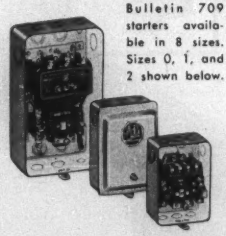
Two thermal breakers give dependable overload protection, no matter how long in service. They are reset by pressing the RESET button.

BULLETIN 709 AUTOMATIC ACROSS-THE-LINE STARTERS UP TO 300 HP, 220 V; 600 HP, 440-550 VOLTS

Dykrex Model M die-finishing machine with Bulletin 709 Allen-Bradley automatic solenoid starter.



Bulletin 709 starters available in 8 sizes. Sizes 0, 1, and 2 shown below.



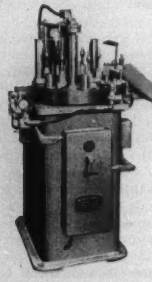
Quality appearance and reputation for reliability make Bulletin 709 starters an asset to any machine.

Bulletin 709 solenoid starters provide the safety feature of no-voltage protection. If the motor is stopped, due to power line interruption, it cannot restart until the operator presses the Start button.

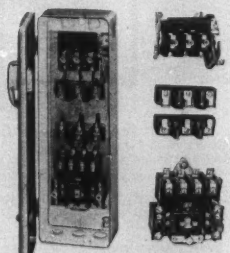
All Bulletin 709 starters have silver alloy, double break contacts that need no filing, cleaning, or dressing. They are good for millions of trouble free operations.

Two overload relays protect the motor against burnouts.

BULLETIN 712-713 COMBINATION AUTOMATIC STARTERS UP TO 100 HP, 220 V; 200 HP, 440-550 VOLTS



Noble & Westbrook Roll-O-Mark marking machine equipped with A-B Bulletin 712 combination starter. Makes a neat & compact installation.



The Bulletin 712 starter combines a visible contact disconnect and a Bulletin 709 starter.

Bulletin 713 combination starters combine, in one enclosure, an I-T-E instantaneous circuit breaker and a Bulletin 709 starter.

Thermal overload relays are standard equipment on all Bulletin 712-713 combination starters.

Bulletin 712-713 starters provide the additional protection that the cabinet cannot be opened unless the disconnect lever is OFF; the starter is then "dead."

Allen-Bradley Co., 1301 S. First St., Milwaukee 4, Wis. • In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

Improved
ELECTRICAL
and
MECHANICAL
PROPERTIES
—make the difference!

morganite

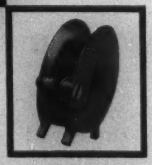
means...

BETTER PERFORMANCE
LOWER MAINTENANCE

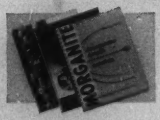
Motor and Generator Brushes
Morganite brushes enjoy a reputation world-wide for trouble-free service. Available for fractional horsepower, aircraft, automotive, traction and industrial applications.

Carbon Brush Holders
Assure high efficiency brush operation by maintaining positive contact between the brush and the commutator or ring. Standard types include cantilever radial, radial, trailing, reaction and AC slip ring holders.

Electrical Contacts
Including drum controllers, contactors and starters. Incorporate metals in a refractory carbon base for improved electrical conductivity and mechanical strength. Contacts are self-lubricating, non-welding.



Carbon Current Collectors
Reduce operating costs on travelling cranes. Cost less, wear longer and reduce conductor wear to a minimum. Will not blister or rough conductor, afford trouble-free service over extremely long periods.



Complete Catalogs Available — call or write today. Recommendations on specific applications supplied promptly on request.

Morganite
INCORPORATED . . . FOR OVER HALF A CENTURY
3308 48th Avenue, Long Island City 1, New York

Manufacturers of Fine Carbon Graphite Products including Carbon Specialties, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts
Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

(Continued from page 60A)

New Products

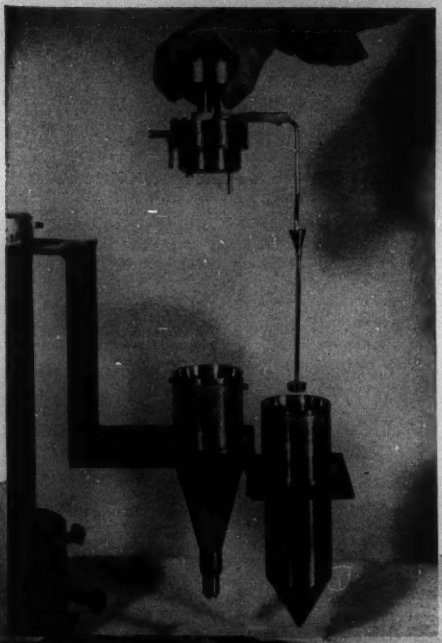
is adjustable via a single colorstat control for proper recording of various types and colors of documents. Film capacity is 250 feet of 16-mm film, which can be loaded in daylight. Automatic feeding equipment and document stacker is available for use with the Model *11*. Further information can be obtained from any Remington Rand sales office located in all principal cities, or by writing to the company.

Miniature Themostat. The miniature "Tempswitch," latest addition to the complete line of Scaico automatic temperature controls, is ¼ inch OD by 1 inch long. Also available is a comprehensive line of switches with various mountings. The Tempswitch has been found useful in precision temperature control, in cathode tubes, and in other applications. Available in plain, flanged, or screwed head mountings, the Tempswitch comes in either a 2-wire or grounded type construction. For further information contact Scaico Controls, Inc., Palmyra, N. J.

Data Recorder and Gauge Tank Unit Tester. A Model *TR-150-14* magnetic tape recorder-reproducer designed specifically for recording and reproducing data from telemetering channels has been announced by Telectro Industries Corp., 35-18 37th St., Long Island City 1, N. Y. Model *TR-150-14* is a rack-mounted 14-channel 3-speed unit. The unit can be supplied to record data from as many as 28 channels. Also developed by the same company is the *MD-2* tester which combines a servo operated selfbalancing 3-terminal capacitance bridge and an extremely accurate megohm meter. The capacitance bridge is designed spcifiecally to measure capacitances to values of 5,000 microunicrofarads ($\mu\mu f$) in three ranges in increments as low as 0.1 $\mu\mu f$. Accuracy is better than 0.5 per cent of full scale ,and measurements are read directly through the use of a main and vernier dial. Additional data may be obtained by writing to the company.

Flashlight Battery. An all new construction, general purpose, flashlight battery has been announced by Bright Star Industries. The new battery, designated as No. *10M Leakproof*, is nationally distributed. The No. *10M Leakproof*, has a steel-reinforced double top and bottom which insures against leakage. In addition, there is the use of double polyethylene plastic film barriers for side insulation, which prevent power dissipation as well as leakage. The No. *10M Leakproof* is electrolyte resistant and is fully insulated against short circuiting. Other features are extra strong fibrous kraft retaining walls and a brass cap for assured conductivity. Samples and detailed information to interested dealers or distributors are available by writing Bright Star Industries, 600 Getty Ave., Clifton, N. J.

(Continued on page 66A)



The apparatus to the left is used for precise alignment of the filtering assembly used in hot cells for RaLa processing. When in actual use it is operated by remote control.

Los Alamos Scientific Laboratory is a non-civil service operation of the University of California for the U. S. Atomic Energy Commission.

This drawing shows the remotely controlled equipment for chemical separation, filtering, drying, pelleting, and jacketing of RaLa sources. Up to 100,000 curies can be handled.

Eimac preformed finger stock is the inexpensive, efficient answer to many circuit and equipment design problems . . .

Used for efficient electrical contact in high-frequency tuning devices, in coaxial tube sockets, for electronic weather stripping around access doors in equipment, and for dozens of other purposes, resilient silver-plated EIMAC finger-stock is outstanding.

EIMAC finger stock is accurately heat-treated to maintain uniform mechanical properties, can be fitted around a ½-inch radius, and may be fastened by screws, rivets, clamps or soft soldering.

A size for every need —

Single Edge	Width	Double Edge	Width	Klystron Types
CF-100	17/32	CF-200	13/16	CF-700
CF-300	31/32	CF-400	1 17/32	CF-800
CF-500	1 3/8	CF-600	2 1/4	

For further information write our Application Engineering Department

Eimac

EITEL-McCULLOUGH, INC.

SAN BRUNO CALIFORNIA

The World's Largest Manufacturer of Transmitting Tubes

(Continued from page 62A)

TRADE LITERATURE

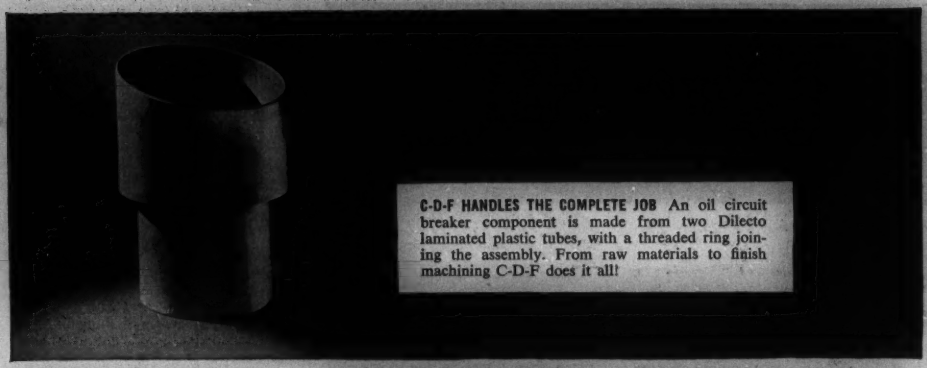
Film Magnetic Tracks. A discussion of laminated magnetic tracks for motion picture film is the subject of "Sound Talk" bulletin No. *33* now available on request from Minnesota Mining and Manufacturing Co., 900 Fauquier St., St. Paul, Minn. The 4-page bulletin illustrates standard track widths and positions which can be applied to 16-mm and 8-mm movie film using the "Scotch" brand magnetic laminate system. Also shown are 10 standard magnetic recording films made by the firm in 16-, 17½-, and 35 mm widths. Details of the laminating process are described and physical and magnetic characteristics of "Scotch" brand No. *121* laminate tape are outlined. The bulletin also lists seven film processors over the country equipped to laminate film.

Polyester Insulation. Two illustrated booklets on polyester electrical insulating products have been published by Insulation Manufacturers Corporation, 565 West Washington Blvd., Chicago 6, Ill. Also published by the company are the following: a revised and enlarged 32-page catalog with descriptive information, photos, prices, and ordering data on electrical insulation materials; an illustrated 20-page catalog on electrical slot insulations, wedges, and fabricated parts, with selection guides and ordering data; and an alphabetical guide to electrical insulating materials. All catalogs mentioned are free of charge.

Diazochrome Slides. A 28-page booklet describes preparation and use of diazotype color slides for overhead projection has been published by Tecnifax Corporation of Holyoke, Mass. The booklet is entitled "Diazochrome Slides for Visual Communication." The introduction to the handbook stresses the importance of visual communication for rapid, efficient transmission of the modern world's rapidly expanding body of knowledge. The relatively new overhead projection technique is recommended as an effective means of communicating ideas visually, particularly for education, training, sales promotion, staff meetings, and executive briefings. Operation of the overhead projector is explained, and several projection techniques are suggested. Production of static and dynamic projection slides is thoroughly covered, including preparation of originals, color separation, opaquing techniques, printing and developing, and mounting. The text is liberally illustrated with drawings, diagrams and photographs. The booklet is printed in four colors and is attractively bound. It may be obtained free of charge by writing to Tecnifax Corporation, 195 Appleton St., Holyoke, Mass.

Pressure Sensitive Tape. A 4-page folder describing the use of Temp-R-Tape, a pressure-sensitive Teflon tape, for class *H* insulation and nonstick facing, is available, along with a sample of the tape,

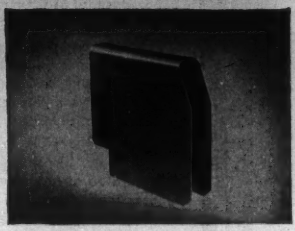
(Continued on page 82A)



C-D-F HANDLES THE COMPLETE JOB An oil circuit breaker component is made from two Dilecto laminated plastic tubes, with a threaded ring joining the assembly. From raw materials to finish machining C-D-F does it all!

C-D-F KNOWS HOW TO MACHINE PLASTICS. A bus bar gets a covering of molded Dilecto over copper supplied by the customer. The plastic ends are skillfully trimmed on a smooth saw.

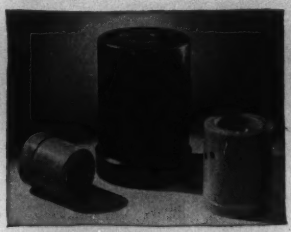
C-D-F MOLDS MANY SPECIALTIES. This shaft insulator for a circuit breaker is molded from C-D-F's cloth-based industrial thermosetting plastic, Celoron. Note complexity of mold, clean detailing.



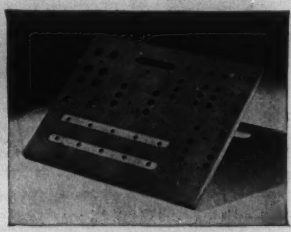
C-D-F USES MODERN METHODS. Large quantities of arc chute barriers are made from paper-based Dilecto. Operations include pressing, cutting, post-forming and trimming.

Dependable equipment relies on C-D-F insulation!

C-D-F OFFERS UNIQUE MATERIALS. This contact shaft for an air circuit breaker is another example of molded C-D-F Celoron used in switchgear because of its high impact strength.



C-D-F IS A SKILLFUL ASSEMBLER. Made from Grade C rolled Dilecto tubing, these pots are turned, bored, slotted. Then a macerated plastic end is inserted and arc resistant varnish finish applied.



C-D-F UNDERSTANDS THE ELECTRICAL INDUSTRY'S NEEDS. Precisely machined to close tolerances, Dilecto panel boards guarantee dependable insulation, help designers save space.

See our catalog in Sweet's Design File for basic product data and sales offices. Write for detailed information, or send us your print for quotation.

CONTINENTAL DIAMOND FIBRE

CONTINENTAL-DIAMOND FIBRE DIVISION OF THE BUDD COMPANY, INC.

NEWARK 86, DELAWARE

The Vacuum Switch Goes to Work

SWITCHING TRANSMITTER ANTENNAS

Jennings RADIO

VACUUM ELECTRONIC COMPONENTS

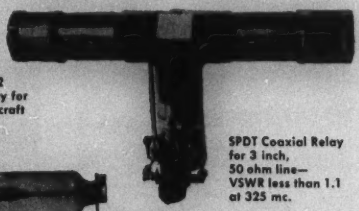
No longer is it necessary to manually switch high voltage rf circuits. No longer is it necessary to fight problems of changing contact resistance or rectification due to the oxides that form on contacts in air.

Jennings vacuum switches have solved these problems. Their clean contacts stay clean since contamination is impossible in a vacuum. And in addition the high dielectric strength of a vacuum makes possible small solenoid actuated relays that can interrupt high voltage circuits with contacts that have to move only a fraction of an inch.

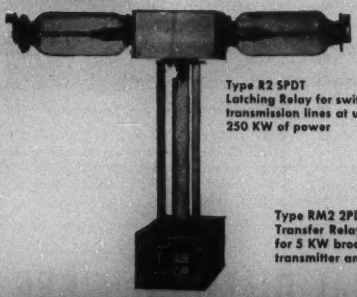
Turn therefore to Jennings with all of your rf switching problems. "Hot" or "cold" rf circuits can be remotely operated at any power level and at any transmission line frequency. Jennings vacuum switches can be used to switch antennas from transmit to receive, from the final amplifier to the driver stage, or from a main transmitter to a standby transmitter. They can be used to isolate a transmitter from its antenna, to switch to one of several antennas or to switch from an antenna to a dummy load. They can also be used for tap changing on rf coils or for switching antenna tuning coils.

We can suggest a relay for many difficult rf, dc, or 60 cycle switching problems if you will send us your circuit conditions.

Type JGF-RE2
Transfer Relay for switching aircraft antennas



SPDT Coaxial Relay for 3 inch, 50 ohm line—VSWR less than 1.1 at 325 mc.



Type R2 SPDT
Latching Relay for switching transmission lines at up to 250 KW of power

Type RM2 2PDT
Transfer Relay suitable for 5 KW broadcast transmitter antennas

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(Continued from page 66A)

Trade Literature

from the Connectiut Hard Rubber Company, 407 East St., New Haven, Conn. The folder mentions uses, gives properties and prices of Tem-R-Tape. The tape is available in 0.006 inch and 0.013 inch thicknesses, ¼ inch to 12 inches wide, in rolls or on a cloth backing with a range of sizes available from stock direct or through local distributors.

Heater Handbook. A vest-pocket edition of the Venturafin Unit Heater Handbook is available from American Blower Corporation, Detroit 32, Mich. The 64-page illustrated handbook (bulletin *9417*) contains specifications and operating characteristics as well as installation and application data for the complete Venturafin line. Designed to be easily carried in a pocket, the handbook is a handy source of unit heater information for on-the-job calculations or conferences. Included in the pocket handbook are such important data as capacity tables, dimensions, engineering specifications, external ductwork suggestions, mounting heights, piping diagrams, pipe sizes, sound ratings, and wiring diagrams. Also included is a typical selection problem together with the recommended easy-to-follow step-by-step solution procedure. Easily understood line drawings are used in a number of places throughout the handbook for further clarification of the data presented.

Tool Engineer Survey. The results of two surveys recently completed by the National Education Committee of the 35,000-member American Society of Tool Engineers are now available in booklet form. The surveys, designed to assist educators in realistic planning of engineering curricula to meet industry's needs, reveal where graduates are employed, in what areas more training is needed, and how present curricula can be changed to better meet actual industry job requirements. Data for the surveys was obtained from mechanical and industrial engineering alumni of five top engineering schools, and from information received from 1,050 companies in the metalworking industries. Among other things they show that one out of every three mechanical and industrial engineering graduates is, or will be, assigned to manufacturing engineering responsibilities, including those of management. For your copy write: American Society of Tool Engineers, 10700 Puritan Ave., Detroit 38, Mich.

I-F Amplifiers. A broad line of i-f amplifiers and preamplifiers using miniature and subminiature tubes is illustrated and described in a four-page brochure. Units described include laboratory types for noise figure measurement, subminiature preamplifier and automatic frequency control units, and general purpose amplifiers for radar and guided missile applications.

(Continued on page 83A)

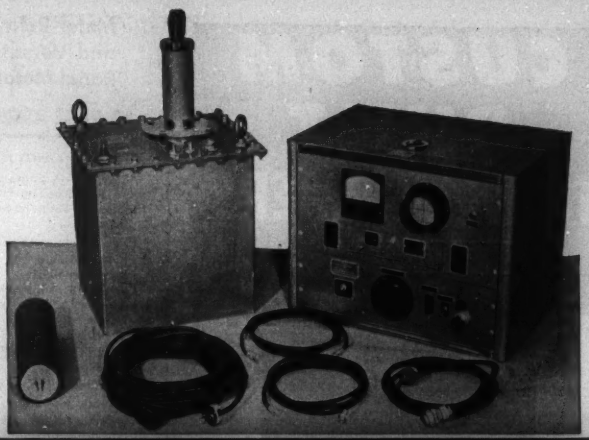
(Continued from page 82A)

Trade Literature

Flexible Couplings. Torsionally flexible, Morflex couplings are fully described in a new 24-page catalog. The Morflex principle, employing preloaded rubber biscuits as the flexible medium, is explained and illustrated. Complete dimensions and specifications are given on standard, double, and radial type couplings with additional data on coupling drive shafts. Torsional deflection charts and instructions for use explain the method of coupling selection in controlling the torsional vibration of a system.

Univac. The advantages of the Univac *120* punched-card computer for engineering use are outlined in a new booklet, "How To Harness the Profit-Power of Electronics," recently published. With this electronic computer's ability to speed through any mathematical or algebraic formula, jobs formerly prohibited by computing costs are now feasible. Mistakes which could wipe out weeks of calculations are completely eliminated. Univac *120* reduces the need for highly paid technical personnel, because it frees engineers and mathematicians from calculating drudgery, lets them concentrate on creative work. In addition, Univac *120* streaks through routine figurework procedures; delivers the reports you want when you want them; digs deeper into workaday figures, coming up with solutions to management control problems; and produces large-scale surveys, analyses, and reports impossible with conventional methods. It is capable of 360,000 additions or substractions an hour in the computing unit, and 72,000 multiplications or divisions. It automatically verifies every internal calculation with no extra program steps or attention from anyone. It can even be set up to catch some human recording errors. Copies of this brochure, *TM-1010*, may be obtained from Remington Rand sales offices in all principal cities or by writing to Remington Rand, Division of Sperry Rand Corporation, 315 Fourth Ave., New York 10, N.Y.

Tape Recorders. The Magnemite (Registered U.S. Patent Office) series, portable, battery-operated, spring-motor magnetic tape recorders are illustrated and described in a 4-page folder available from Amplifier Corporation of America. The brochure completely describes in detail, features of 15 models, all of which were especially designed for field applications. A variety of single and multispeed models are available (two-, three-, and four-speed). A complete listing with performance characteristics is tabulated for easy reference and to simplify selection. Various mechanical and electrical components are fully described and individually illustrated. The recorders' operating features are concisely explained and complete technical specifications as well as direct factory prices are included. The brochure may be obtained without cost by writing to: Amplifier Corporation of America, 398 Broadway, New York 13, N. Y.



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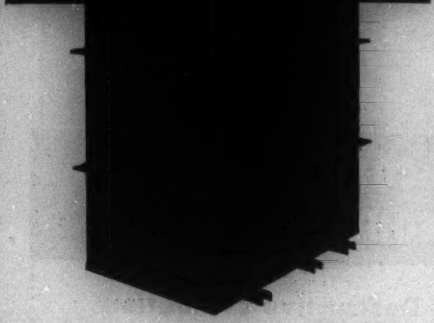

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